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Tracts and Observations

IN

NATURAL HISTORY

AND

PHYSIOLOGY.

WITH SEVEN PLATES.

K

BY ROBERT TOWNSON, L.L.D.

F. R. S. EDIN. AUTHOR OF THE PHILOSOPHY OF MINERALOGY;

AND TRAVELS THROUGH HUNGARY.

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Index and Observations

NATURAL HISTORY



P R E F A C E.

THE two first Tracts in this volume were published in Germany, a few years ago, in Latin; the third was written about the same time, but not published. It is these three papers that have principally induced me to give this volume to the public, for I found, when I wished to lay before them merely these physiological observations, that the booksellers were unwilling to have any concern with such a trifle; I was, therefore, almost compelled to make up a volume. I was the less unwilling to accede to this, as most of the other tracts were in my portfolio, and I have always thought, that every man of science and observation,

should consider both his cotemporaries and posterity as having a claim upon him for his discoveries and remarks, and should therefore consider it as a social duty to leave them upon record. This is my apology, if any should be thought requisite, for publishing those papers that form the latter part of this volume; some of which, I must observe, were written eight years ago.

CONTENTS.

	Page.
<i>ON the Respiration of the Amphibia in general</i>	7
<i>On the Respiration of the Frog-Tribe</i> —	16
<i>Anatomy of their Instruments of Respiration</i>	21
<i>Defence of the preceding Doctrine of Respiration of the Frog-Tribe</i> - - -	31
<i>On the Respiration of Lizards in general</i> -	41
<i>On the Respiration of the Salamander</i> - -	42
<i>On the Respiration of the Water-Lizard</i> -	44
<i>On the Absorption of Fluids by the Skin of some of the Amphibia</i> - - - -	50
<i>On the Respiration of Tortoises</i> - - -	85
<i>On the Degree of Cold that Frogs can endure</i> -	104
<i>Miscellaneous Remarks on Frogs</i> - -	107

	Page.
<i>Remarks on the bony Structure of Frogs and Lizards</i> - - - - -	108
<i>On the Question, whether some Serpents have two Lungs or only one</i> - - - - -	116
<i>A new Division into Families of the Genus Testudo</i> - - - - -	112
<i>On the Voracity, &c. of some of the Amphibia</i> - - - - -	113
<i>On the Structure of the Bill of the Cross-Beak</i>	116
<i>On the final Cause of some Animals being white in Winter, and in northern Climates</i> -	124
<i>On the Structure of the Husk of the Oat</i> -	127
<i>On the Cause of Objects appearing Single, though viewed with both Eyes</i> - - -	130
<i>Objections against the Perceptivity of Plants, so far as is evinced by their external Motions</i> -	137
<i>On a Plica in a Hare</i> - - - -	146
<i>On the common Rabbit producing Angora Rabbits</i>	148
<i>On clearing Corn from Weevils</i> - -	149
<i>On the Measurement of Fishes</i> - - -	150
<i>Of the Julus Oniscoides</i> - - - -	151
<i>On the final Cause of our Aversion to tread on soft Bodies, &c.</i> - - - -	153

CONTENTS.

ix

	Page.
<i>On the Instinct of a Mouse</i> - - -	156
<i>On the Bull-Finch</i> - - -	157
<i>A Sketch of the Mineralogy of Shropshire</i> -	158
<i>Remarks on the Mineralogy of the Environs of Edinburgh</i> - - - -	204
<i>A Sketch of the Mineralogy of the Malvern Hills</i> - - - -	216
<i>On Millstone-Rocks</i> - - - -	221
<i>On Stone-benge</i> - - - -	227
<i>Remarks on the Flos-ferri</i> - - -	229
<i>On a Group of Cristals of Selenite inclosing Drops of Water</i> - - - -	231
<i>On the Tremella Nostoc</i> - - - -	232

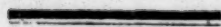
CONTENTS

ix	
125	On the subject of a House
127	On the subject of a House
128	A House of Representatives
	House of Representatives of the United States
129	House of Representatives
130	House of Representatives
131	House of Representatives
132	House of Representatives
133	House of Representatives
134	House of Representatives
135	House of Representatives
136	House of Representatives
137	House of Representatives
138	House of Representatives
139	House of Representatives
140	House of Representatives
141	House of Representatives
142	House of Representatives
143	House of Representatives
144	House of Representatives
145	House of Representatives
146	House of Representatives
147	House of Representatives
148	House of Representatives
149	House of Representatives
150	House of Representatives
151	House of Representatives
152	House of Representatives
153	House of Representatives
154	House of Representatives
155	House of Representatives
156	House of Representatives
157	House of Representatives
158	House of Representatives
159	House of Representatives
160	House of Representatives
161	House of Representatives
162	House of Representatives
163	House of Representatives
164	House of Representatives
165	House of Representatives
166	House of Representatives
167	House of Representatives
168	House of Representatives
169	House of Representatives
170	House of Representatives
171	House of Representatives
172	House of Representatives
173	House of Representatives
174	House of Representatives
175	House of Representatives
176	House of Representatives
177	House of Representatives
178	House of Representatives
179	House of Representatives
180	House of Representatives
181	House of Representatives
182	House of Representatives
183	House of Representatives
184	House of Representatives
185	House of Representatives
186	House of Representatives
187	House of Representatives
188	House of Representatives
189	House of Representatives
190	House of Representatives
191	House of Representatives
192	House of Representatives
193	House of Representatives
194	House of Representatives
195	House of Representatives
196	House of Representatives
197	House of Representatives
198	House of Representatives
199	House of Representatives
200	House of Representatives

Physiological Observations

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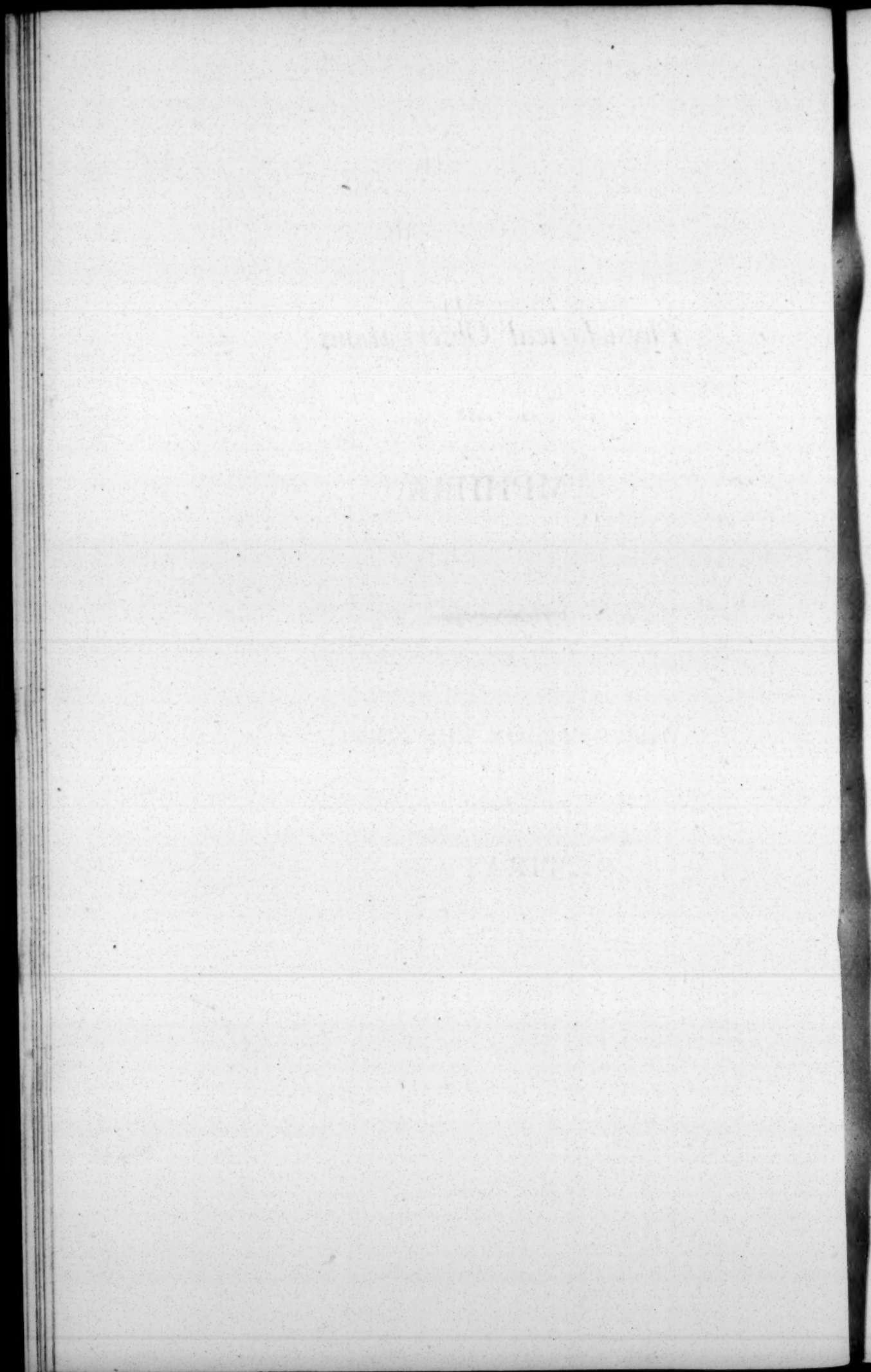
AMPHIBIA.



DISSERTATION THE FIRST,

ON

RESPIRATION.



TO
Dr. MONRO,
PROFESSOR OF ANATOMY, &c. &c. &c.

IN THE
UNIVERSITY OF EDINBURGH,

THIS DISSERTATION

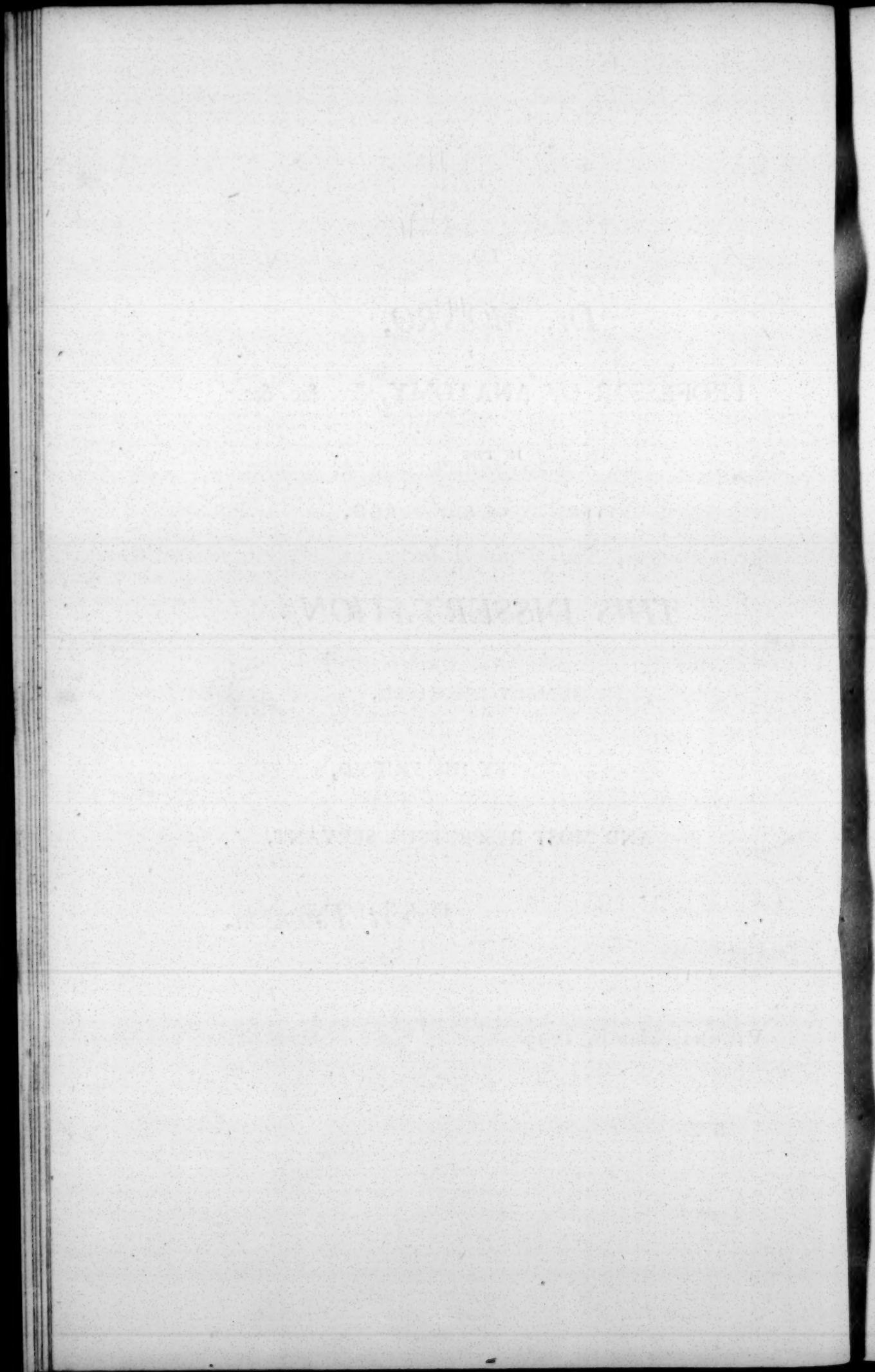
IS HUMBLY INSCRIBED,

BY HIS FRIEND,

AND MOST RESPECTFUL SERVANT,

Robert Townson.

VIENNA, March, 1793.



INTRODUCTION.

SO immensely varied and complex are the works of nature, that, after the accumulated labours of the learned of many ages, there is still ample room to institute enquiries, with the animating hope of making new discoveries. I, therefore, think it needless to make any apology for entering on the present subject of investigation, convinced, as I am, that though I may not prosecute it with the success that greater talents might, I shall, at least, shew that there is ample room for enquiry, and that I have not left my subject in the state I found it.

How far I shall continue my investigations I know not; this must depend upon leisure and opportunities.

INTRODUCTION

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ON THE

Respiration of the Amphibia.

THE necessity of respiration to the support of life, and the evident injuries arising from any impediment in this function, induced the earliest medical philosophers to make it a subject of enquiry; and, from that time to this, it has afforded a continued subject of admiration, discussion, and dispute: not, indeed, of dispute, as whether it was necessary or not, but why it was necessary? what were the advantages the animal economy derived from thence? and by what means it was carried on?

The question, why it was necessary? led to disputes, if we exclude those of modern times, far more subtle than sound; but the question, how it was performed? has led to a diligent investigation of the organs by which it is car-

ried on, and has ultimately brought physiologists to this conclusion: that the lungs, themselves, are inactive in respiration, not being possessed of an inherent active power to expand in inspiration, nor any, or scarcely any, to contract in expiration, but that these two different and alternating states of the lungs depend on the cavity of the thorax being enlarged in the first case, and diminished in the latter; and that through the medium of the ribs, the intercostal muscles, and the diaphragm. The ribs being elevated by the intercostals, whilst the diaphragm is depressed, the thorax is enlarged, and the air then rushes into the lungs, according to the laws of pneumatics: this is inspiration. Afterwards the ribs fall, and the diaphragm rises, by which the cavity of the thorax is diminished, the lungs compressed, and the air contained is expelled: this is expiration, and in these two actions consists respiration. Yet, though the ribs are requisite to a full and sound respiration, the history of medicine relates cases in which, the ribs having become motionless through disease, the diaphragm has been found sufficient to carry on an imperfect respiration, with the assistance of the abdominal muscles.

These enquiries and experiments, however, were instituted chiefly upon hot blooded animals, and justly, while the object was to explain this function in them and in man; but, before it was applied to so very dissimilar animals as the Amphibia, it ought to have been enquired into, whether the structure of these warranted it? Certainly it does not; yet the doctrine of respiration of the former has been almost universally applied to the latter, and that without any discrimination.

Although the poor Amphibia, by being so easily procured, and being so tenacious of life, particularly Frogs, have, upon every difference which has arisen amongst medical philosophers, perished by thousands, yet we do not find that this frequent inspection of their structure, has led to any discovery of the nature of the function of respiration in them, nor served to elucidate that of the hot blooded animals. This is rather to be wondered at, as the comparison of such dissimilar structures might very naturally have been used to explain the offices of the different organs. — In the writings of some old authors, we, indeed, find a few accidental observations which might have led to some discovery in this part of the physiology of

these animals; but history, as well as daily experience, proves, that we may proceed to the last step towards a discovery and advance no further.

As early as Aristotle this difference was observed, between some of the Amphibia and hot blooded animals, that in the former the lungs did not collapse on opening their containing parts, as in the latter. The celebrated MALPIGHIVS and ROESEL observed this peculiarity in the Frog tribe, and COITER and VARNIER in Tortoises and Serpents. This, in different tribes of this class, arises from very different causes, which we shall afterwards assign. It is now universally known that the lungs of Frogs do not collapse on cutting through their containing parts, but often protrude through the wound, and will remain inflated after their containing parts are cut away; and, what is more remarkable, if in this state they should collapse the animal can again inflate them. This, surely, strongly indicates a very different mechanism in the organs of respiration, and of this we shall be immediately convinced.

We have already observed, that the principal organs of respiration were the diaphragm

and the intercostal muscles with the ribs, but in the Amphibia there is no diaphragm. The celebrated HALLER says, in his Physiology, “*Frigidi sanguinis animalia, quæ ego quidem vidi, aut nihil habent diaphragmati simile, aut membranaceum.*” PANAROLO says this of the Chamelion. BLASIUS found none in Lizards, and VALENTINI and CHARAS none in Serpents; and there really is none. The lungs, which are large and cellular, nearly occupy the whole length of the body, and are not separated from the other viscera. It cannot, however, be denied, that some have asserted to have found a diaphragm in some of these animals. But if we reflect that these anatomists never doubted that respiration was performed in them as in hot blooded animals, and that there necessarily must therefore be a diaphragm, and then turn to the descriptions which they have given us of it, as that of BORRICHIVS, who, though speaking of the diaphragm of so large an animal as the Crocodile, says, is so thin “*ut vix tela araneorum tenuior æstimari possit,*” or the descriptions of those who say that it is merely membranaceous, we shall be confirmed in our opinion, that the Amphibia have no diaphragm adapted to respiration.

Some even of the animals which are now the subject of our consideration, as the Frog tribe, and that family of the Lizards, which LINNEUS calls the Salamanders, are not only destitute of the muscular parts used in respiration, but are even destitute of the bony fabric which renders these serviceable.—They have no ribs.

Although respiration is not so obviously necessary to life in the Amphibia as in the hot blooded animals, yet no one could doubt of their breathing, and the means being obscure or concealed, by which this is performed, some celebrated physiologists have been led to attribute to some parts of these animals powers and modes of acting, repugnant to sound physiology. DUVERNEY and TAUWRY, according to GUALTER, conceived Tortoises to breathe only in walking; and VARNIER confidently asserts, that the lungs contract and dilate by a power residing in their own proper muscles. The great HALLER, when speaking of the contractile power of the *aspera arteria* and the *bronchia*, attributes to the human lungs a contractile power, which, he says, “ad musculosam aliquam, etsi parum oculis conspicuam, fabricam pertineat;” and supports this

opinion by the expiration of the Amphibia, observing that they can, at pleasure, empty their lungs so that they collapse, and that, as this change does not arise from the weight of the air, nor any difference in temperature, it must be caused by a muscular texture. Very lately a German physiologist and lecturer on comparative anatomy, professor BLUMENBACH, in his tract on the comparative physiology between hot and cold blooded animals, attributes to the lungs of amphibious animals, a power which he calls *vita propria*. This is going back to the antiquated idea of occult faculties, and is nothing more than a *vis respirandi*, which no better explains the matter than the *horror vacui* of the ancients.

The opinion of this learned professor, who I believe is the last that has written on this subject, so aptly shows in what obscurity it is still enveloped, that I shall transcribe the passage. “ Pulmonibus amphibiorum, (says he), singularis concessa est prærogativa, qua humani et aliorum mammalium destituuntur, tonus nempe et energia peculiaris, cujus virtute aperto etiam thorace, et si externo expositi sint aeri, turgentes tamen et stabiles sese sustinere possunt, cum mammalium e contra

pulmones, simulac sternum remotum et thoracis cavitates apertæ fuerint, collabantur et desideant." In support of his opinion, he then gives us the experience of Coiter, who says: "quid quod et studio compressus testudinum vivæ sectioni subjectorum pulmo proprio impetu denuo seipsum inflare possit;" and then makes this conclusion, "Causa hujus virtutis vix aliunde, quam ex vita horum viscerum propria derivanda videtur, cum neque ad contractilem, neque ad irritabilitatem, neque ad nerveam vim ullo modo referri possit.—Texturæ enim vero musculosæ non magis quid quam in amphibiorum pulmonum superficie detegere potui, quam in iis calidiorum animalium, quibus nimis liberaliter irritabilitatem tribuere videtur nuperrimus de eo argumento Auctor Cel. Varnier."

Nothing, certainly, but the difficulty of explaining how respiration is performed in these animals, could have induced him to attribute that effect to a *vita propria*, or particular tone and energy, which must be attributed to muscular powers, as its efficient cause, wherever the exciting cause might have its seat. But it is not to be wondered at, that he should not have been satisfied with the accounts

which are to be found in almost every elementary work on Physiology and Natural History, for these say little more than that nature has given to these animals arbitrary lungs, by which means they can live without breathing much longer than hot blooded animals. This, certainly, is of great consequence in their economy, but has no connection with the mechanism of respiration.*

I shall now, after these general remarks, proceed to elucidate this obscure subject, and it will appear, as I proceed, that, even in the class of Amphibia, the mechanism of respiration is not uniformly the same, but various.

* Whilst I was writing this dissertation, the *Synopsis Reptilium* LAURENTI, by accident, fell into my hands, and I was not a little surprised to read the following character, amongst others, of his Classis Reptilium; "Pulmone instructa, sine diaphragmate et fere sine costis, at vicaria gula quæ alternatim ærem haurit et contracta in pulmonum propellit." Although this work is referred to by all who have since written on the Amphibia, I know of no author who has mentioned this remark, nor of any physiologist who has profited by it: it is certain, however, that the mechanism of respiration of the Frog tribe was known to Laurentius.

On the Respiration of the Frog Tribe.

I HAVE stated the absence, in this tribe of amphibia, of those parts, as well osseous as muscular, which, in hot blooded animals, serve for respiration: I shall now shew how this defect is supplied, and point out the admirable contrivance of nature, which enables them to fill their lungs with air, without the means of forming the ordinary vacuum.

If we look at quadrupeds, we observe no motions in the throat, except those attendant on deglutition; but if we look at any of the Frog tribe, whether awake or asleep, except when submerged, we see very remarkable motions which are quick and constant. These motions, however singular it at first may appear, are the motions of inspiration, or rather serving for inspiration. By the same instinct that hot blooded animals are taught to relieve the sensation of suffocation, by alternately enlarging and diminishing the capacity of the thorax, these are instructed to dilate and con-

tract the throat; here the vacuum is formed. The cavity of the throat being enlarged, the air rushes in through the nostrils and fills it; the nostrils are then closed by their proper muscles, the glottis is opened, the muscles designed for this office contract, diminish the the cavity of the throat, and impel the contained air into the lungs; in this way is inspiration performed in these animals,

When the lungs were laid bare, I have observed that these did not inflate, if the Frog, exhausted with pain and loss of blood, or when the nostrils were covered with it, opened its mouth to take in a greater supply of air, till the throat contracted; this, then, was the immediate consequence. Likewise, if I put a tube down the throat, the glottis and mouth being by this kept open, the lungs collapsed, and in this state remained; but as soon as the tube was removed, respiration immediately recommenced: nothing similar to this is to be observed in hot blooded animals.

Expiration is very easily accomplished; for, the *glottis* and the nostrils being open, the lungs by their own contraction from a state of distention, and by their own weight, aided

by that of the superincumbent parts, will gradually expel the air ; but the muscles which cover the sides act also on this occasion, and in their croakings, (which, in the time of their amours, are heard to a great distance), with great force. But in the ordinary expirations of these animals, no more than in quadrupeds, do the lungs wholly collapse ; if not viewed with attention, no motion is ever perceived in their sides, though there is a regular contraction and distention. They likewise have the faculty of compressing one lobe of the lungs singly, by the contraction of the muscles of that side ; this is easily induced by touching them gently on the side with a pin or other sharp body.

As these animals are known to be able to live a much longer time without air than those with hot blood, it has been said by many that they respire slower. “ *Rarissimæ* (says Haller), *sunt respirationes animalium frigidorum.*” Though probably they do not vitiate so much air, they respire very rapidly. Man respire about twenty times in a minute ; and, according to FORGARO, birds, which breath the quickest of all hot blooded animals, from twenty-five to fifty ; but the Esculent Frog

(*Rana esculenta*), respire about seventy times in a minute; the *Rana variabilis* (a species of Toad), about a hundred, and the Tree Frog (*Rana arborea*), so rapidly that I could not reckon the number of the motions of its throat. The contractions of the throat I have considered as inspirations; yet, as the nostrils do not close with each contraction, I cannot venture to affirm that at each the whole contents of the throat are driven into the lungs. As there is frequently one contraction in four or five greater than the rest, it may be then that the greatest quantity of air is driven into them. When these animals sleep, and in cold weather, these motions are slower and more feeble.

According then to the doctrine which I have advanced on the mechanism of respiration in the Frog tribe, which may easily be subjected to experiment, and then thrown aside, if it bears not this test, but candidly received if it does, their lungs possess no secret power of dilatation, any more than those of hot blooded animals. In both, this organ is inactive in respiration, which process, principally differs in this, that, whilst in the

HOT BLOODED THE AIR IS SUCKED INTO

THE LUNGS BY THE EXPANSION OF THE THORAX, IT IS DRIVEN INTO THEM, IN THE FROG TRIBE, BY THE MOTIONS OF THE THROAT.

Let us now proceed to examine anatomically the mechanism subservient to respiration; and when, for the sake of brevity, in speaking of the throat, I make use of the terms of muscles of inspiration and expiration, I mean by the former those muscles which serve for forming a vacuum in the throat, and by the latter those which serve to diminish it.

Anatomy of the Instruments of Respiration.

WHEN the skin is stripped off from the throat, a broad muscle comes into view which is the *mylo-hyoideus*. It covers the whole throat, being extended from the end of the *maxilla* to the *condyles*; its fibres run transversely, and are inserted into the *maxilla* through its whole length. In the middle, from the point of this bone, it becomes thin and membranous, but at the *condyles* thicker; it is not united with the *os hyoides*, as in man, but slightly connected with the skin. When the cavity of the throat is diminished, its muscular fibres are seen evidently to contract, but chiefly at the *condyles*, where the muscle is thickest. Thus, this muscle seems well adapted to assist in driving the air from the throat into the lungs; nevertheless if it be cut away respiration continues.

The *mylo-hyoideus* being cut away, the *genio-hyoidei* appear; and, under these, in the middle, is the muscle of the tongue; the muscle at the point of the *maxilla*, the *sterno-*

byoidei and the *coraco-byoidei* are likewise seen. The *genio-byoidei*, which are slit where the *sterno-byoidei* are inserted in the *os-byoides*, from their direction and connection, ought, one would think, greatly to assist in drawing the *os byoides* forwards, and, by this means diminish the cavity of the throat; yet these being cut away respiration continues.

The *sterno-byoidei* are strong and powerful; they rise from the whole length of the last bone of the sternum, and are inserted all along the *os byoides*. As the *os byoides* is not in the same direction as the sternum, but higher, and its *cornua*, which are fastened by the *stylo-byoidei*, likewise higher and oblique, these muscles in their contractions draw this bone downwards and backwards, and thus form a cavity in the throat. These are the principal muscles used in forming this cavity, and when they are cut respiration ceases.

The *coraco-byoidei* rise from the inferior side of the neck of the *scapula*, and are inserted into the *os byoides* near the insertions of the *sterno-byoidei*. They direct the movements of the *os byoides*, and draw it downwards; one being cut, this bone loses its natural direction and inclines to the other side.

If we search deeper, we find the *stylo-hyoidei* muscles, otherwise the *constrictores medii Pharyngis*,* of which there are three pairs.† One pair, which is stronger than the rest, rises from the posterior region of the ear, and is inserted into the points of the *cornua* of the *os hyoides*. The other two pairs have the same origin, and are likewise inserted into the *cornua* of the same bone, but more forward. These muscles are likewise of great moment in contracting the cavity of the throat by elevating the *os hyoides*, and drawing it forward. I have observed some muscular fibres in the vicinity of the *stylo-hyoidei*, upon the membrane which lies immediately under the muscles now described, and which forms the interior part of the throat; these may assist likewise as constrictors.

If we take away the muscles and the membrane of the throat, leaving only the *sterno-hyoidei* muscles, although respiration is now totally destroyed, the motions used in respi-

* Either the *stylo-hyoidei* or these constrictors are wanting.

† In the common Toad (*Rana Bufo*), and in the *R. variabilis*, I only found two pairs.

ration continue. The *os hyoides* is still drawn backwards and forwards, and the *glottis* opens and shuts, but the lungs remain collapsed; if even all the muscles which move the *os hyoides*, are cut away, the *glottis*, whose muscles remain untouched, continues to open and shut, just as in hot blooded animals, whose respiration is destroyed by a large wound in the thorax, efforts to respire continue, though ineffectual, to remove the painful sensation of incipient suffocation.

On expiration little is to be said; I have always found the lungs of these animals, whether alive or dead, to collapse as soon as the *glottis* is open; yet, as I have already observed, the oblique muscles, which extend from the *glottis* to the *os pubis*, and thus envelope the lungs through their whole extent, have a great power to compress them, and thus produce expiration. Whether I have properly applied the name of *obliques* to these muscles I will not contend, as I have not examined them with particular care; they may probably be composed of several muscles, but thus much I have observed, that their fibres run more or less transversely, and are therefore well adapted to produce this effect.

PLATE I.

FIGURE 1.

Represents part of a Frog lying on its back.

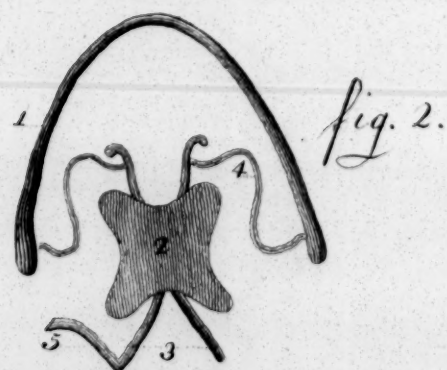
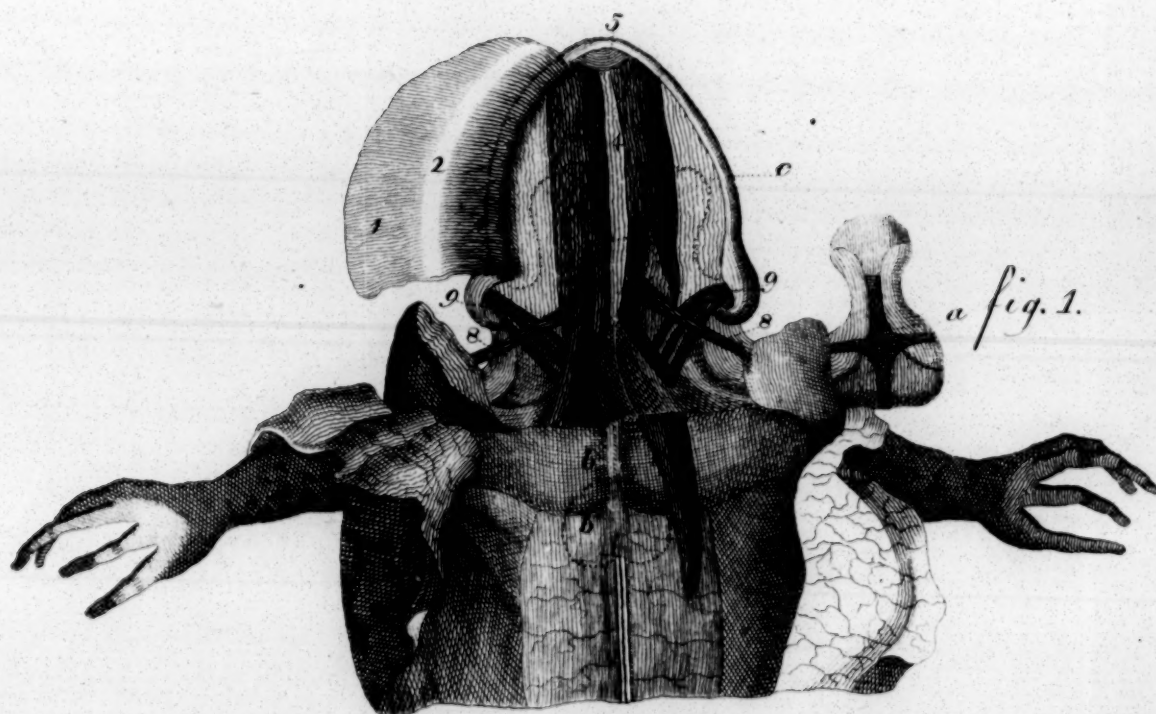
- a. Part of the sternum cut and turned back.
- b. Part of the sternum in its natural situation.
- c. The inferior maxilla.
- 1. The mylo-hyoideus muscle.
- 2. Where the same becomes membranous.
- 3. The genio-hyoidei muscles.
- 4. The muscle of the tongue.
- 5. The muscle of the apex of the maxilla.
- 6. One sterno-hyoideus in its natural situation.
- 7. The other turned back.
- 8. The coraco-hyoidei muscles.
- 9. The stylo-hyoidei muscles.

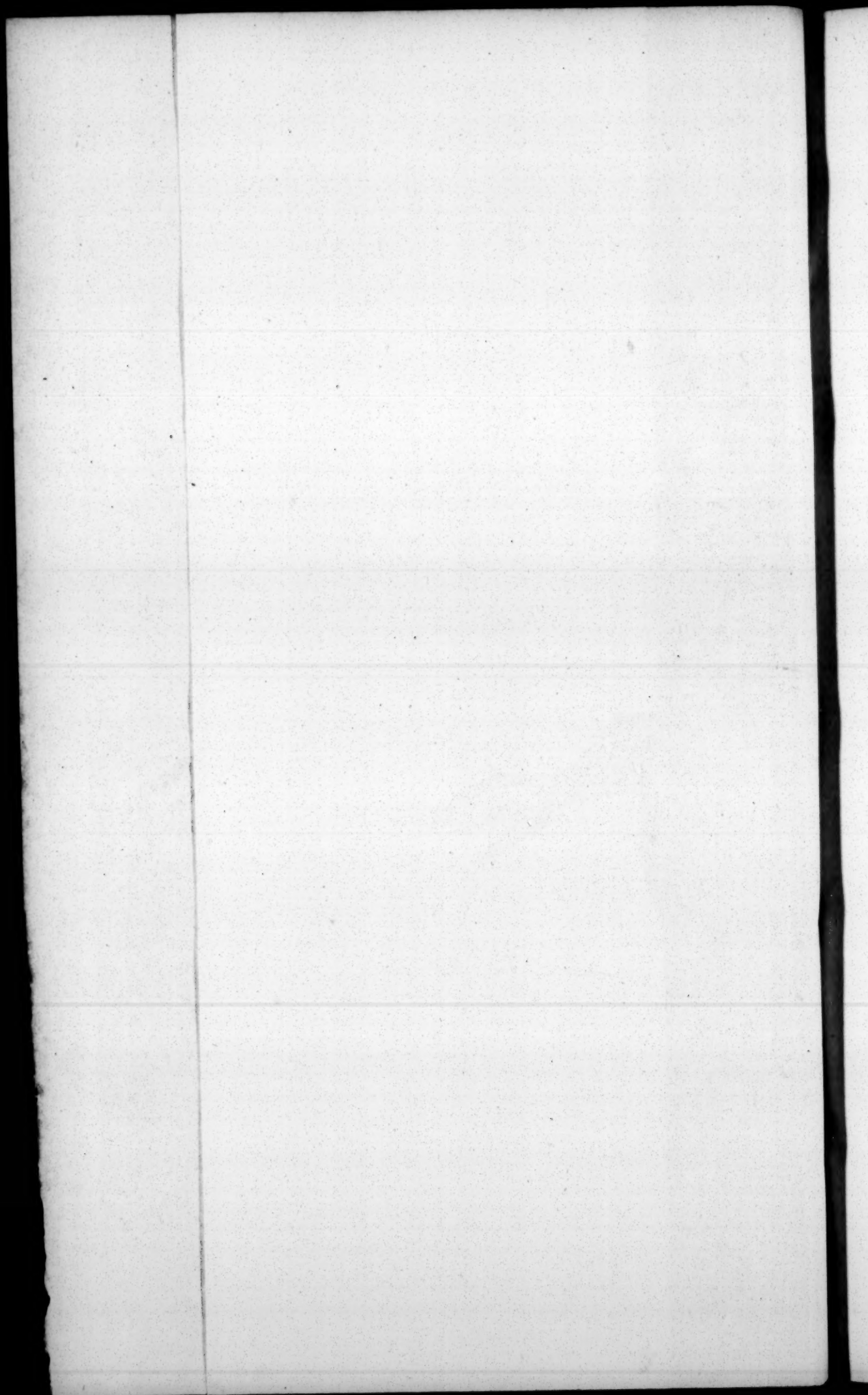
The Dotted line shews the outline of the os hyoides and its cartilaginous appendices.

FIGURE 2.

- 1. The inferior maxilla.
- 2. The os-hyoides
- 3. Its cornua.
- 4. Its cartilaginous appendices.
- 5. One of the principal stylo-hyoidei muscles.

Tab. 1.





Physiological Observations

ON THE

AMPHIBIA.



DISSERTATION THE SECOND.

Respiration continued;

WITH A FRAGMENT UPON THE SUBJECT OF

ABSORPTION.



TO
Dr. BLACK,
PROFESSOR OF CHEMISTRY
IN THE
UNIVERSITY OF EDINBURGH, &c. &c. &c.

THIS
DISSERTATION

IS HUMBLY INSCRIBED,

BY HIS FRIEND,
AND MOST RESPECTFUL SERVANT,

Robert Townson.

GÖTTINGEN, 1795.



Respiration continued.

WHEN I published the first dissertation, from having found nothing in the course of my reading similar to the explanation which I gave of the mechanism of respiration, I was induced to think that I was the first discoverer of it; and I was further led to think so, by the coinciding opinions of several excellent physiologists, to whom I communicated it. In none of the Zootomical Compilations of SEVERINUS, BLASIUS, VALENTINI, or *Les Memoires pour servir à L'Histoire Naturelle*; in none of the works of those who have treated professedly on the Genus Rana, or Frog tribe, as JACOBÆUS; nor in the works of those who have extended their labours to the whole class of amphibia, as CEPEDE; nor in HALLER's great work on Physiology, where the functions of the human body are so often elucidated by comparative anatomy, and where such frequent references are made to

zootomical writers, any more than in many modern elementary books of physiology and anatomy, could I find a hint concerning it, though other parts of the physiology of these animals, neither so striking nor so important, had not been neglected, and where even the subject of respiration had been treated of. But the few words of LAURENTI, which I have already quoted, undeceived me.

Since then I have found that it was known to SWAMMERDAM; for he says,* “*Sic in Rana resectis musculis tum abdominis tum pectoris, imo denudato etiam corde, respirationem (si ita appellare liceat) musculorum oris ope, (quod ipsi prægrande est) adhuc perfici experti sumus:*” and, in another place† he says; “*vidi etiam cum sic equitantes respirarent, cutem externam, quæ tympanum auditus, utpote proxime subter hanc pone oculos, constitutum, supervestit, jugiter inde nunc elevari, nunc iterum subsidere: ut hinc sane visu pereligans nascatur spectaculum, quando ambæ simul respirant, et suas quæ-*

* Tractatus de Respiratione, page 85.

† Bib. Naturæ, page 809.

libet nares alternis aperiunt et constringunt.”—MORGAGNI mentions it, likewise, in his *Adversaria Anatomica*.^{*} And that it was known to MALPIGHIUS, is evident, by his answer to ENTIUS,[†] in which there is this remarkable passage; “Primo namque constat ex oculari inspectione, ranas ad libitum, aperto etiam thorace proprios exinanire folliculos, et mox etiam turgidos reddere. Et licet in reliquis animalibus aperto thorace, et subeunte externo aere, simulque comprimente pulmones, inspiratio in iisdem impediatur, in ranis tamen, in quibus costulae desiderantur, natura peculiari organisatione supplevit, addendo concavitationem, qua receptus aer in expositos folliculos exprimitur, tanta vi, ut pressionem ambientis aeris superet.—Insignis igitur in ranis occurrit buccae concavitas, cui geminae appenduntur lateraliter vesicae membranosae carnis fibris munitae; superior vero buccae concameratio osseo excitatur operimento; pars vero inferior cum membranosae et laxa sit, compressa exterius gibba fit, et ita ampliorem reddit buccam;

^{*} *Advers. Anatom.* 5, *Animad.* 29.

[†] *Opera Posthuma*, page 8.

totum autem hoc ita succedit. Laryngis corpus ossibus hinc inde positis circumseptum deorsum, versus imum ventrem fibris carneis, quasi septo transverso retrahitur; et ex plano elongata mucronata cartilago, cum analogo quasi sterno deorsum curvatur, et ita subsequitur amplitudo buccae, sicut accidit nobis deprefso septo transverso, et extra magis incurvata thoracis concavitate. Aer itaque per geminos narium hiatus, in quibus necessario valvulae locantur, expiratur, quibus compressione facta, et angustata bucca, aer protruditur per laryngem in continuatos pulmones; aperta namque laryngis rimula et appressis oris labiis vi detruditur in proximos pulmones, a quibus ad nutum animalis diducto iterum laryngis hiatu et contractis fibris carneis in rete implicatis, et pulmones amplectentibus, juvante externi aeris pondere, rursus in buccam revocatur, et ita respiratio celebratur; hinc ablata inferiori praecipue mandibula, cum buccae concavitas patula reddatur, nulla succedit, pulmonum inflatio.—In testudinibus, laceris, viperis et consimilibus thoracis structura costulis et musculis integrata observatur; pulmones quoque trachea oblonga cum larynge muniuntur, ita ut eadem omnino phaenomena

in his succedant, quae in perfectorum animalium respiratione deprehenduntur.”

I cannot, therefore, lay claim to the merit of being the first discoverer of this anomalous mode of respiration ; yet I may claim that of elucidating it, if obscure, of reviving it, if forgotten, and of re-establishing it, if laid aside as erroneous. It has been declared to be an obsolete opinion of the older anatomists, by a learned professor in one of the first Universities of Germany, in a public course of lectures on comparative anatomy ; not merely taking from me the merit of the discovery, but giving me the demerit of reviving an old erroneous opinion, which, by subsequent experiments, had been overturned, laid aside and forgotten. “ Quo magis dignus laude, (says Morgagni in defence of Valsalva*), Valsalva est, et erit quicunque obsoleta et pro falsis jam habita antiquorum inventa suis ipse observationibus in pristinam lucem splendoremque restituat. Hunc ego non dubitem vel primis illis earundem rerum inventoribus anteferre. Illi enim verum duntaxat do-

* Morgagni Epistolae Anatomicae.

cuerunt; hic simul tum falsum dedocet, tum verum docet; turpius autem est, quod verum sit, pro falso habere, quam verum ipsum ignorare. Huc illud addendum est, quod multo difficilius accidit, ut res, quae vulgo falsa credatur, confirmetur, quam ut nova quaequam reveletur; nam si quis in illam forte incidat, ob opinionem tamen praejudicatam facile negligit, se fallasia quadam decipi, suspicans, aut id quod videt fortuito factum existimans; quo fit, ut non sine pluribus ac saepius repetitis inspectionibus nec sine longiori examine atque acriori possit ejusmodi res in antiquam lucem revocari; et quod hinc sequitur, ut si ab exercitato et sapienti viro revocetur, ejus multo magis rei, quam alterius prorsus novae, certi esse posse videamur."

The refutation of this opinion, I believe, the learned professor thought he had found in Mr. Bremond's paper, in the Memoires of the Royal Academy of Paris for 1739; the intent of which is to prove that the lungs are not passive in respiration, but in themselves possess a power to expand and contract; which opinion he himself has adopted.

Nothing distinguishes this paper so much as the false conclusions that are drawn from

the experiments instituted; and it is by one of these that Mr. Bremond thought he had overturned that part of the explanation of Malpighi, where, he says, that the lower *maxilla* being cut away, the Frog can no longer inflate its lungs. Mr. Bremond expresses himself thus: “ On lit dans les oeuvres posthumes de MALPIGHI in fol. page 8, qu’ayant coupé la Machoire inferieure de la grenouille, et decouvert la cavité de la gorge, les poumons ne peuvent plus se dilater, mais il paroît par les experiences que je viens de rapporter, que cet habile anatomiste s’est trompé.” But if we read with the greatest attention the experiments of Mr. BREMOND, we are not induced to doubt those of MALPIGHI. The experiment which he, I suppose, thought invalidated the observations of this great man, must be that where he cut the cartilages of the *glottis*; but this should not prevent the air from being driven into the lungs and their consequent inflation, like cutting off the lower maxilla; these two parts performing quite different functions. But what is truly surprising, is, that after giving in detail the explanation of MALPIGHI, and giving his assent to it, for he expresses himself

thus, he should reason as though he had never heard of it, or did not believe it, “ La gorge de la grenouille a une structure très particuliere; par le moyen des muscles, décrits par MALPIGHI, cet animal peut tantôt la dilater considerablement et tantôt la diminuer. Lorsque la Bouche et les narines sont ouvertes, la grenouille remplit d’air ou en partie, ou entierement sa gorge, ensuite fermant sa bouche et ses narines, elle ouvre la glotte et par la contraction des muscles de la gorge et des autres muscles voisins, elle presse l’air vers son larynx et le détermine à entrer dans les poumons; elle peut par cette artifice en admettre la quantité, qu’elle veut: de meme en resserrant ses poumons et dilatant sa glotte, elle chasse autant d’air qu’elle le desire, ou totalement ou en partie; c’est dans cette mecanique que consiste le coasement.”

If he admits of the explanation of MALPIGHI, how inconsistent it is to make the following queries: “ mais si l’air pouvoit par son poids affaïfser les poumons des quadrupeds, pourquoi n’affaïfseroit-il pas ceux de la grenouille? cela devoit arriver, quand la provision d’air que la grenouille a faite, est épuisée, ou quand elle a coasée, ses poumons

étant à decouvert ; aussitôt que ses poulmons seroient une fois affaîsés par l'expiration volontaire de l'animal, pourroient-ils se dilater de nouveau ? si l'on lui suppose une force à l'orifice de la glotte, qui retienne l'air captivé dans les poumons, pourquoi ausitôt que cette force est vaincue, le poumon se dilate-t-il de nouveau après s'être contracté ? J'ai introduit plusieurs fois la pointe d'une epingle ou d'un scalpel dans l'orifice de la glotte, j'ai fait à l'instant affaîser le poumon, et j'ai vu faire à l'animal une violente expiration, cependant aussitôt après le poumon s'est dilaté de nouveau, et ne s'est contracté qu'au bout de quelque tems ;" and a little further, he says, " ayant fait secher des poulmons de grenouilles soufflés, j'ai tres bien vu le réseau de fibres charnues et musculaire qui enveloppent et recouvrent les poumons de la grenouille. Ces fibres doivent avoir beaucoup de force dans ce viscère et servir également, quoique d'une façon differente, pour sa contraction et sa *dilatation*." Now can any thing be more inconsistent, than after saying that MALPIGHI had discovered that the Frog had the throat so formed as to be able to drive the air into the lungs, to ask how it is that the lungs are inflated after they are laid bare ?

On reconsidering the matter, I am no ways inclined to change my opinion, either from the experiments and reasoning of Mr. BREMOND, nor from the opposition and assertions of the learned Professor; nor induced to reject a rational and mechanical explanation, perfectly consistent with the animal economy, and fly to occult powers, which, by sagacious philosophers, are justly considered as mere delusions, and injurious to the advancement of science. “*Operatio ejus, (says the great BACON), prorsus similis est soporificis nonnullis medicamentis, quae somnum conciliant, atque insuper laeta et placentia somnia immitunt. Primo enim intellectum humanum in soporem conjicit, decantando proprietates específicas et virtutes occultas et coelitus demissas, unde homines ad veras causas eruendas non amplius excitantur nec evigilant, sed in hujusmodi otii acquiescunt; deinde innumera commenta somniorum instar insinuat et spargit.*”— I will now quit this controversy, and, with my scalpel in my hand, proceed, according to my design, to investigate the mechanism of respiration in the other Amphibia.

On the Respiration of LIZARDS.

OF this very numerous genus, consisting of near eighty species, and divided into eleven families, most of which are the inhabitants of the warmer climates, I have only hitherto had opportunities to examine two or three species of the family of the Salamanders, and the common Lizard (*Lacerta agilis*) of the family of the *Ameiva*. From my restricted observations, it would be too rash to speak in general of the whole genus; yet, as far as my observations have extended, I am induced to divide them, so far, I mean, as concerns the subject of respiration, into two divisions; into those without ribs, and into those with ribs. The former are by far the least numerous, and probably only consist of the family of the *Salaman-dræ* of Linneus; these have short moveable bones fixed to the lateral processes of the vertebræ, but no ribs; and those with ribs will probably include the remaining ten families.

In this chapter it is only my intention to speak of those without ribs, and these have so great a similarity with the Frog tribe, that, after what I have said on them, there is but little to say on these; for the mechanism in general is the same, yet the difference in the shape of their bodies has rendered some variation requisite.

On the Respiration of the SALAMANDER,
(*L. Salamandra*. LINN.)

THE same motions which I described in the throat of the Frog, are to be seen in this animal. They are nearly as rapid as in the Tree Frog; but the greater motions, accompanied by the closing of the nostrils, take place more seldom, only two or three times in a minute, yet they are more distinct than in the Frog.

The principal differences which I observed on dissection, were in the *os hyoides* and its muscles; and in the connection of the *sterno-hyoidei* muscles. The *os hyoides* is entirely cartilaginous, and on each side there is a cartilage running parallel to its cornua;

Pl. I. will shew better their shape and relative situation than any description. Its muscles, likewise, differ greatly from those of the Frog; instead of the *stylo-hyoidei* are substituted two muscles, one running from the further end of its cornua to the fore end of the lateral cartilage, into the hind end of which is inserted the other, which rises from the apex of the maxilla. These muscles, from their very oblique direction in respect of the cartilages to which they are connected, must have great effect.

The *sterno-hyoidei* muscles are very remarkable; this animal has no distinct *sternum* or *clavicles*, but very large *scapulas* chiefly cartilaginous, the greatest part of which comes forward where the two meet and cover the breast. These being loose and playing upon one another, the *sterno-hyoidei* muscles, instead of rising from hence, as from the *sternum*, rise at the *os pubis*, on the side of the Y cartilage, and then run between the oblique muscles up to the *os hyoides*; in the region of the heart they throw off a small muscle towards the *processus coracoideus*; this, I suppose, is the *coraco-hyoideus*, or its substitute. In the greater motions of the throat, the *sterno-hyoidei* draw

the *os hyoides* nearly into a vertical direction, that is, a right angle with the direction of the body.

The WATER LIZARD. (*Lacerta lacustris*. LINN.)

THIS animal so much resembles the preceding in the function of which I am treating, and in the mechanism by which it is performed, that I might have passed it over in silence, were it not on account of the very singular structure of the lungs.

The *os hyoides* and the lateral appendages are like those of the Salamander in shape; but they are bony, except at the ends nearest the apex of the maxilla. The *sterno-hyoidei* muscles, as in the Salamander, rise from the *os pubis*, which has likewise the Y cartilage.

In its natural element, which is the water, this animal breathes seldom; only about once in a quarter of an hour. For this purpose it comes to the surface of the water, opens its mouth, sends out a bubble of air, instantly swells its throat, which it as rapidly contracts, and then immediately retires. If even it

should remain near the surface of the water, yet this business is done in an instant, and as it were by stealth; and none of the smaller motions of the throat are observed. But as soon as it is taken out of this element, and the water has run from off its nose, and its nostrils are clear, it begins to move its throat, and that as rapidly, or more so, than the Salamander; these motions are accompanied by the greater ones and the closing of the nostrils; but if water is dropt on the nostrils all these motions cease.

The lungs demand our particular attention. This organ, (were not men, when their vanity opposes the humiliating acknowledgment of error, stubborn to the soundest arguments, and even invincible by the clearest demonstrations,) would shew the fallacy of attributing to the lungs of the Amphibia an inherent power of inflation. They are, really, as JACOBÆUS calls them, *sacculi aëriæi*,* and com-

* “ Duo oblongi sacculi aëri recipiendo dicati, pulmones constituunt, qui valde nitidi ac pellucentes ab initio oesophagi ductum alimentorum comitantur et ad ovaria usque protenduntur. Vasa sanguinea secundum longitudinum pulmonum cum ramis suis minutissimis decurrunt.” Jacobæus Observat. de Ranis.

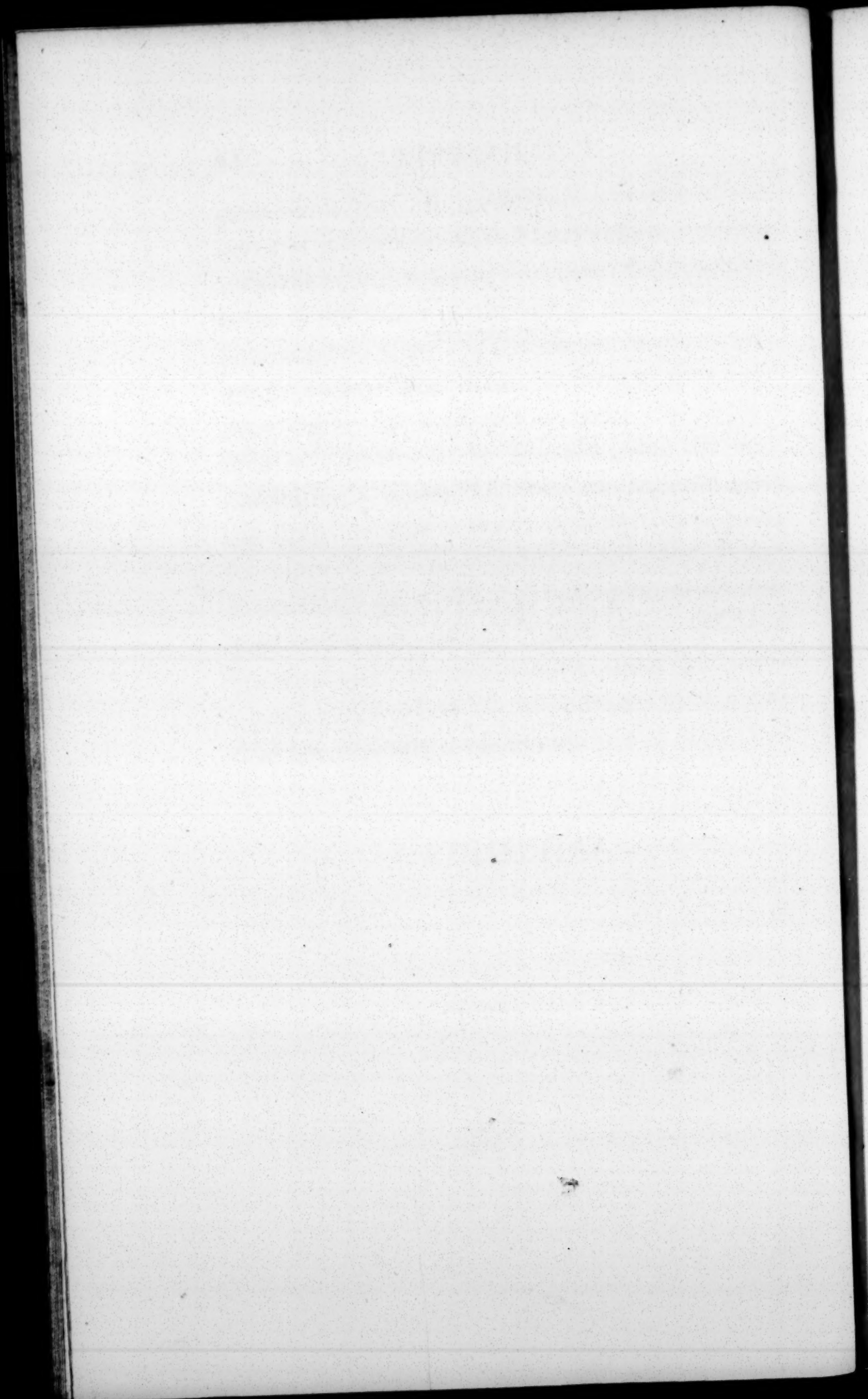
posed of a fine thin membrane like the *vesica aërea* of fishes; yet with blood vessels running upon them, but entirely destitute of the parietal cells of the lungs of the Frog tribe and the Salamander. Can any texture, even muscular, adapt bodies like these to form a vacuum? Any one in the least acquainted with mechanics will immediately acknowledge the impossibility. VARNIER must never have seen the lungs of this animal, else he would not, in support of his opinion, that the lungs themselves were the immediate cause of respiration, have said, “ que cette fonction (respiration) depend comme dans les *Amphibies* de la dilatation et contraction alternative des *vesicules* du poumon.”

ON THE

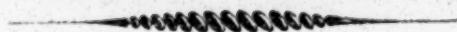
ABSORPTION

OF THE

AMPHIBIA.



IT was my intention, when I began these Physiological Observations, to have gone through the function of Respiration in all the different tribes of the Amphibia, before I entered upon a different subject; but the difficulty I have found to procure some of them has induced me to change my plan, and here to begin with another subject.



WHAT an important office the skin performs in the animal economy is in general well known to Physiologists, yet executing its office in secret, its utility in some animals has been greatly overlooked. How very important it is to the Frog and Salamander tribes I shall shew in this dissertation; when it will appear, that while those Animals, with whose economy we are best acquainted, receive their principal supply of liquids by the mouth, THESE TAKE IN THEIRS THROUGH THE SKIN ALONE: ALL THE AQUEOUS FLUID WHICH THEY TAKE IN BEING ABSORBED BY THE SKIN, AND ALL THEY REJECT BEING TRANSPIRED THROUGH IT.

Near three years ago, when the chilling cold of winter was coming on, a large female Frog (*Rana temporaria*) was brought to me. I put it in an earthen jar with water in my

room, which being warmed by a stove it shewed no signs of torpidity. Though the jar was above a foot deep, it used to come out and make excursions in my room, and in a few Hours retire: almost every evening it came out, but before I was up in the morning it had leaped into the jar again. This continued through a great part of the winter, when a favourite hedge hog stole in from an adjoining room and ate it. During this time I had occasion to observe, that when I forgot to replenish the jar with water, or when it had remained a longer time than usual out of the jar, it grew meagre, emaciated and feeble; but speedily recovered its *embonpoint*, strength and vivacity on being put in its favourite element: this observation induced me to turn my thoughts to this subject.

In the spring some Tree-Frogs (*Rana arborea*) afforded me excellent opportunities of observation, for they soon grew tame and seldom left the window appropriated to them where they had a bowl of water. But if they did, and got down on the floor they became very soon lank and emaciated; and if not taken up in a few hours they were so debilitated, that though replaced in the water they

never recovered. When the weather was dry and hot and the sun shone bright upon them they often retired to a more shady place; if they did not they were, in a few hours, obliged to seek the water. They seldom failed going into it in the evening, except in damp and cold weather; they would then frequently stay out two days. If I took the bowl away, and dropped a few drops on the board, they applied their bodies as close to it as they could, and again looked plump,

I observed, likewise, in some common Frogs, which were on the floor and had no water, that they got into a box of sawdust, in which they nearly covered themselves, and in this they remained alive much longer than if exposed to the air. These were but rude experiments, but they strongly indicated so peculiar and anomalous an economy, that I thought it worthy of further enquiry, and I instituted the following suite of experiments, and others which I have lost, to determine the quantity of water absorbed and transpired.

 FIRST EXPERIMENT.

A Tree-Frog which I believe had not been in the water during the night, and weighed 10 shot, was placed on the rim of a glass of water; it entered and remained in half an hour; when it came out it weighed $14\frac{1}{2}$; it had therefore absorbed in this short time nearly half its own weight of water—at

$\frac{1}{2}$ past 11 in the morning it weighed	$13\frac{1}{2}$ shot
8 in the evening	$11\frac{1}{2}$
10 at night	$11\frac{1}{4}$

At night I took away the bowl of water, and in the morning I found it had left the window and had crept into a corner of the room, and was covered with dust and almost lifeless; I cleaned it and it weighed only $7\frac{1}{2}$ shot. I then repeatedly washed it on the upper surface of its body with a hair pencil imbibed with water, and by this it gained 2 shot in weight; after this I left it about an hour and it lost half a shot, weighing only

9 shot. I then put it into a glass of water, where it remained an hour and a quarter, it then weighed $13\frac{3}{4}$; so that in this short time it had absorbed $4\frac{3}{4}$, a little more than half its weight, and was now nearly double the weight it had been when I found it in the morning.

SECOND EXPERIMENT.

Another Tree-Frog, at

	SHOTS.	
8 at night weighed	13	
10 ditto	12	
$5\frac{1}{2}$ morning	22	It had, therefore, been in the water.
$11\frac{1}{2}$ ditto	$19\frac{3}{4}$	
$3\frac{1}{2}$ afternoon	18	
$7\frac{1}{2}$ ditto	$17\frac{1}{2}$	
10 ditto	$16\frac{1}{2}$	
6 morning	$15\frac{1}{2}$	Soon after it entered the water, and remained in an hour, and was at
8 ditto	$18\frac{3}{4}$	
$9\frac{1}{2}$ ditto	18	
4 afternoon	$15\frac{1}{2}$	
10 night	13	

THIRD EXPERIMENT.

Another Tree-Frog, which had been without water all night, and looked very much emaciated, weighed $7\frac{1}{2}$ shot. I placed it on blotting paper, fourfold, and well soaked with water ; on this it remained an hour and a half, and then walked off ; it now weighed 14 shot. It had, therefore, in the short space of an hour and a half, and by the under surface of the body alone, absorbed nearly its own weight of water.

FOURTH EXPERIMENT.

The next experiment was made with two very fine female Toads, which had been without water nearly two days, and were very weak and much emaciated. One of these, weighing $34\frac{1}{2}$ large shot, was put into water nearly three hours, and then weighed 57 : the other, weighing $32\frac{1}{2}$, after remaining about three hours on wet blotting paper, weighed 39.

Whilst I was at Göttingen, in August 1792, I kept a journal, for eighteen days, of the increase and decrease of weight of two favourite Tree-Frogs, male and female, which, for amusement, I had named Damon and Musidora.

DAMON.

AUGUST.				SHOTS.
Saturday	11.	6 morning, he weighed		$14\frac{3}{4}$
		10		$14\frac{1}{4}$
		12		13
		$3\frac{1}{2}$ afternoon		11
Sunday	12.	6 morning		13
Monday	13.	6 morning		14
		8		$13\frac{1}{2}$
		12		12
		$6\frac{3}{4}$ afternoon		$10\frac{1}{4}$
		10		9
Tuesday	14.	6 morning		$12\frac{3}{4}$
		12 noon		12

MUSIDORA.

AUGUST.

SHOTS.

Friday 10. At $5\frac{1}{2}$ morning she weighed 20, she then ejected a little water, and at

7	....	....	....	19
12	....	....	....	17
4	afternoon	....	....	16
7	....	....	....	$15\frac{1}{2}$
10	....	....	....	13

Saturday 11. 6 morning 21
 10 20
 12 19
 $3\frac{1}{2}$ afternoon $17\frac{1}{4}$

Sunday 12. 6 morning 20
 10 night 14

Monday 13. 6 morning 20
 8 $19\frac{1}{2}$
 12 $17\frac{1}{2}$
 $6\frac{3}{4}$ afternoon 15
 10 14

Tuesday 14. 6 morning she weighed 21, she then ejected a good deal of water, and only weighed $19\frac{1}{4}$
 12 noon $17\frac{1}{2}$

DAMON.

AUGUST.				SHOTS.
Wednes. 15.	7 $\frac{1}{2}$ morning	he weighed		12 $\frac{1}{4}$
	12 $\frac{1}{2}$	....	....	11 $\frac{1}{2}$
	8 afternoon	....	....	10 $\frac{1}{4}$

Thursday 16. 6 morning At night
I could not find him he had left the window.

Friday 17. He had returned to the window, was
dirty and ill looking, and at
6 morning only weighed 8 $\frac{1}{2}$, He then
went into the water, and at
2 afternoon weighed 12
8 $\frac{1}{4}$
10 $\frac{1}{4}$

Saturday 18. 6 morning 10 $\frac{3}{4}$
10 10 $\frac{1}{4}$
1 afternoon 9 $\frac{3}{4}$
10 at night he was in the water.

Sunday 19. 6 morning 13

MUSIDORA.

AUGUST.

SHOTS.

Wednesday	15.	7 $\frac{1}{2}$ morning	she weighed	18 $\frac{1}{2}$	
		12 $\frac{1}{2}$ noon	....	....	17 $\frac{1}{2}$ she had
					therefore only lost 1 shot in 5
					hours; this was a rainy morning.
		8 afternoon	....	15 $\frac{1}{4}$	Then
		she ejected some water, and only weighed		14 $\frac{1}{4}$	
Thursday	16.	6 morning	....	....	18 $\frac{3}{4}$
		10 night	....	....	16
Friday	17.	6 morning	....	....	15
		2 afternoon	....	....	13 $\frac{1}{2}$
		8 $\frac{1}{4}$	....	....	12 $\frac{3}{4}$
		10 $\frac{1}{4}$	....	....	12 $\frac{1}{4}$
Saturday	18.	6 morning	...	....	21 $\frac{3}{4}$ — She
		then ejected some water, and weighed			20 $\frac{3}{4}$
		10	....	....	20 $\frac{1}{2}$
		1 afternoon	....	....	20 — She
		ejected again, a good deal of water, and weighed			17 $\frac{1}{2}$ she had
		therefore ejected 2 $\frac{1}{2}$ shot. — In the evening I found her on			
		the floor, covered with dust; after being cleaned, at			
		10 at night she weighed			14 $\frac{3}{4}$
Sunday	19.	Hour forgot	....	....	20
		4 afternoon	....	....	18 $\frac{1}{2}$ — She
		then ejected some water, and at			
		5 weighed	....	....	17 $\frac{1}{4}$

DAMON.

AUGUST.		SHOTS.	
Monday	20.	6 morning, he weighed a gloomy and rainy day, and in 16 hours he only lost one shot.	13 This was
		12 noon	12 $\frac{1}{2}$
		10 night	12
Tuesday	21.	6 morning a gloomy and rainy day.	11 $\frac{1}{2}$ likewise
		2 afternoon	10 $\frac{3}{4}$
		10 night	10
Wednes.	22.	6 morning probable he had not been in the water, and in the night had only lost a $\frac{1}{4}$ of a shot. 3 afternoon, a rainy and gloomy forenoon, but fine afternoon	9 $\frac{3}{4}$ It is most 9
Thursday	23.	6 morning 11 night	13 10 $\frac{3}{4}$
Friday	24.	6 morning rainy day, he only lost 1 shot in 14 hours. 8 afternoon	12 $\frac{1}{4}$ A gloomy 11 $\frac{1}{4}$
Saturday	25.	6 morning	10 $\frac{3}{4}$
Sunday	26.	Observation omitted	
Monday	27.	6 morning 4 afternoon	13 10 $\frac{3}{4}$

MUSIDORA.

AUGUST.

SHOTS.

Monday 20. $6\frac{1}{2}$ morning she weighed $18\frac{3}{4}$ —From
 this time till $8\frac{1}{2}$ aft. when she weighed $17\frac{3}{4}$ She
 had been kept in a damp medium.

Tuesday 21. 6 morning $16\frac{3}{4}$
 2 afternoon 16
 10 $15\frac{1}{4}$

Wednes. 22. ^e6 morning 15
 3 afternoon 14

Thursday 23. 6 morning $17\frac{1}{2}$
 11 night $15\frac{1}{4}$

Friday 24. 6 morning $14\frac{1}{2}$
 8 afternoon 13

Saturday 25. 6 morning $19\frac{1}{4}$
 8 afternoon $17\frac{1}{4}$

Sunday 26. 6 morning $16\frac{1}{4}$

Monday 27. 6 morning $19\frac{1}{2}$
 4 afternoon $17\frac{1}{2}$

I then set out on a journey to Vienna on horseback, and took my favourite Musidora in my pocket in a little box; by being careful that she should bathe herself every night, she bore the journey very well, though by taking a circuitous road it lasted six weeks. During my travels through Hungary she lived with my worthy and learned friend Professor Jordan at Vienna. In the autumn of 1793 we returned together to Göttingen, and in the month of August of the following year I made some more experiments of the same kind. These I shall relate as they were made with known weights; and the reader may then see, not only the relative, but the real quantity in grains of water absorbed and evaporated. The other experiments, which, when I made, I never thought of giving to the public, only shew the relative quantity.

One day when Musidora looked mean and meagre I weighed her; she weighed 95 grains; I then put her in the water, where she did not stay above an hour; when she came out she weighed 2 drachms and 42 grains or 162 grains, she had therefore absorbed 67 grains, that is 1 drachm 7 grains, which is about 2-3ds of her weight. Soon after, the

weather being rainy, cold and gloomy, she did not move for near two days, and appeared almost torpid, nor did she, I believe, go into the water during this time. Late in the evening seeing her going to bathe herself, I put her in the scales and she weighed 99 grains; I then put her in the water, and when I weighed her next morning, at 8 o'clock, she weighed 156, so had increased 57 grains.

	GRAINS.			GRAINS.
She weighed at 9 at night	134	lofs. therefore	22	
8 next morning 141		gain	....	7
next morning 168		gain	....	27
8 at night	152 $\frac{1}{2}$	lofs	....	15 $\frac{1}{2}$
8 next morning 142		lofs	....	10 $\frac{1}{2}$
9 at night	129 $\frac{1}{2}$	lofs	....	12 $\frac{1}{2}$
8 next morning 120 $\frac{1}{2}$		lofs	....	9
9 at night	105 $\frac{1}{2}$	lofs	....	15
8 next morning 160		gain	....	54 $\frac{1}{2}$
9 at night	140	lofs	....	20
8 next morning 126		lofs	....	14
9 at night	113	lofs	....	13
8 next morning 158 $\frac{1}{2}$		gain	....	45 $\frac{1}{2}$
10 at night	121	lofs	....	37 $\frac{1}{2}$

The sun had shone very bright the greatest part of the day, on the window where she was; this no doubt was the cause that, in the last experiment, the evaporation was so great. She then left the window and for the first time this year; and when I found her on the floor

in the morning at 9 o'clock she weighed $90\frac{1}{2}$ grains; loss $30\frac{1}{2}$ since the last time I weighed her, but 68 grains since the last time she was in the water. I placed her on the rim of her bowl, she immediately went in; two hours after I found her out; now she weighed 152 grains, gain $6\frac{1}{2}$.

The extremes in her weight, in the last suite of experiments, where not the least compulsion or art was used to procure either a great evaporation or absorption, were

168 grains the greatest.

$90\frac{1}{2}$ the least.

$77\frac{1}{2}$ difference.

In the 3d experiment 14 the greatest.

$7\frac{1}{2}$ the least.

$6\frac{1}{2}$ difference.

In the 1st experiment $14\frac{1}{2}$ the greatest.

$7\frac{1}{2}$ the least.

7 difference.

From whence it appears, that these animals sometimes absorb nearly their own weight of water, and, as in the third experiment, in the short time of an hour and a half, and by the under surface of the body alone; this certainly is truly remarkable.

As one alteration in a piece of mechanism renders other changes requisite, so one deviation from the common structure of an animal requires a correspondent difference. It is so I think in the present instance. These animals have a peculiar structure corresponding with the great power of absorption.

In relating the above experiments, I have mentioned that they sometimes eject water: this is done with considerable force, and the quantity is great, as may be seen by the observation on *Musidora* Saturday 18th, when, at two different times, she ejected to the amount of 3 shots and an $\frac{1}{2}$, which is a quarter of her own weight, as the night before she weighed only $12\frac{1}{4}$.

This ejection of water is no new observation, though it has been chiefly noticed in Toads. It has been considered as their urine, and as poisonous, and they are accused of ejecting it with a mischievous intent. As far as my observations extend, it is common to all the Frog-tribe, but I conjecture that it is neither urine, nor ejected as an ordinary evacuation, nor given them by nature as a poisonous and missile weapon, to be used in their defence; but that it is pure water, and only

voided as an incumbrance previous to their efforts to escape. To all of them, on such occasions, so much liquid in the bladder would certainly be very inconvenient, and particularly to those which leap.

From long observation, I am convinced, though these animals have a bladder, and for the size of the animal, a very large one, that they never void urine. What, then, is this fluid, and what is this receptacle? I am uncertain; but I am less inclined to consider the bladder as a *vesica urinaria*, and its contents as urine, which is the received opinion, than to suppose the former to be a reservoir, and the latter a pure fluid to supply the deficiencies caused by transpiration. Or shall we suppose, that this is secreted by the kidneys, but instead of being ejected as urine, that it passes off by perspiration; these two, perspiration and urine, in our economy, have considerable analogy.

Analogy, when observations are wanting, is our safest guide. Those animals, with whose economy we are best acquainted, which have a bladder, void urine, and their ureters invariably terminate in the bladder; but in the Frog-tribe they do not terminate in the bladder,

though ROESEL has drawn them so in Tab. b. fig. 11. of his beautiful work on these animals; saying, at the same time, “Bini alii canales urinam e renibus in vesicam deferentes.” SWAMMERDAM, indeed, supports him with these words: “Super recto collocata cernitur vesica urinaria duplex, in quam urina per ureteres, qui simul vasorum deferentium munere funguntur, deducitur.” But in another place he says: “Vesiculae et vasa deferentia proxime infra fundum vesicae urinariae in intestinum rectum inseruntur.” They certainly terminate in the rectum, as represented in the annexed figure, and this must be the opinion of Swammerdam, though in the first citation he has expressed a different opinion; for in the first citation, he says, that the ureters serve the office of the *vasa deferentia*, and in the last, he says, the *vasa deferentia* terminate in the rectum, which is the same as saying, that the ureters terminate in the rectum. That this is his meaning, is clear, from the following passage: Hic vero probe animadvertendum est, quod renes suum quoque lotium per idem istud deferens vas, per quod testiculi in coitu semen suum, excernant; quemadmodum in

hominibus etiam semen atque urina eandem per urethram evacuantur."

Though the ureters do not terminate in the bladder, there is a large opening from it into the rectum opposite to their termination, so that in the natural position of the animal, the urine might, I think, fall through this opening, which is shut and opened at will, into the bladder; but not in the posture which the Tree-Frog and the other *Hylæ* are often in; yet this would be a singular structure. Birds which never void urine, have likewise their ureters terminating in the rectum; the same is said of the common Lizard. (*Lacerta agilis*.)

Whatever this fluid may be, it is as pure as distilled water, and equally tasteless; this I assert as well of that of the Toad, which I have often tasted, as that of Frogs. The Toad is an unjustly persecuted animal, and is daily an innocent sufferer for crimes invented by fear and prejudice, and listened to by cruelty.* It is still the object of comparison

* I recollect reading in an old book in the Göttingen library of an old woman being got with child by a Toad!!!

for every thing that is odious, hateful, and loathsome. It is treated as an outcast from the goodness of Providence and humanity from man; it is a thing for women to shriek at, and for children to torture.

As the Frog-tribe never drinks, and yet has so great a want of water, it seems to me probable, that this fluid, which is absorbed by the skin, or some part of it, may be conducted to this bladder as to a reservoir, from whence it is further distributed as their economy may require, in the same manner as this fluid taken into the stomach of other animals is from thence further distributed; whilst the urine is conducted by the ureters into the rectum, and is ejected with the other fæces as in animals destitute a bladder.

Snakes, and the common Lizard, which have a hard exterior coating, drink; whether Tortoises, which have likewise a hard coating, do, I am uncertain, but I think they do not. In the *testudo orbicularis*, which is a fluvatile Tortoise and amphibious, I have observed a peculiarity which has some analogy with what I have related of the Frog-tribe. One of these animals, which I kept in my study, I observed, after being out of water for three or

four days, always to extend its neck to the utmost on being put in the water, and to remain in this position nearly motionless for several minutes; though I gave it worms it would not offer to eat till this was over. When I first had it, it used to let out a good deal of water on being taken out of this element, but not after it was accustomed to be handled. I could not doubt that whilst it was in this posture it sucked in water by the anus, and I confirmed this opinion by putting it in water coloured with lackmus, and afterwards drawing off this coloured fluid with a catheter.

I know too little about these animals to venture to say any thing further on the subject, but I know from my own observations on the *testudo orbicularis*, and from the old work of Caldesi, that the bladder in these animals is more varied and far more complex than in other animals. Perrault says of the great land Tortoise, which he examined, that its bladder was of an extraordinary size, and contained above twelve pounds of a clear watery urine.

I now return to the Frog-tribe. The power which this tribe possesses of absorbing so much humidity by the skin, and the reservoir they are provided with for retaining more

than what is proper to enter the system at one time, are of the greatest importance in their economy. Some of them pass much of their time on land, and make excursions far from their favourite element; here this reservoir serves them like the stomach of the Camel when travelling over the parched deserts of Arabia. Some, when the breeding season is over, fix their residence far from any water, and become quite terrestrial animals; during the day, being nocturnal animals, they lie concealed, by which evaporation goes on slowly, but when evening comes they go forth, and, while waiting for their little prey, by applying their bodies to the moist soil, or grafs wet with dew, they make up the loss by evaporation; or if a shower falls they fill their reservoir. The power they have at will of increasing or diminishing their bulk, by blowing themselves up by the inflation of their lungs, or suffering them to be flaccid, must considerably facilitate this business. How readily they must absorb the dew the third experiment shows, and the following will prove that they absorb the moisture from the soil.

A large Edible Frog, (*Rana esculenta*) which, from hopping about my room, where

I had neglected to put a bowl of water, and was became lank and feeble, went into a box of damp mould in which I kept worms, and half covered itself in it; after being cleaned it weighed 6 drachms and 32 grains: I then placed it again on the mould, and a few hours after, at 8 o'clock in the evening, it had gain'd $5\frac{1}{2}$ grains; at 8 in the morning $\frac{1}{2}$ a grain, at 9 at night 2 grains more. Soon after it left the mould, and at 8 in the morning I found it had lost 38 grains. I placed it again on the mould and at 9 at night it weighed the same; at 8 in the morning it had gained 1 grain. When it continued to weigh the same it must not be inferred that it had not absorbed any thing, as it had gained by the under surface what it had lost by the upper. The difference in the quantity, in a great measure no doubt, depended on the dampness of the mould, which, when first turned up, would be moister than when it had been exposed some time to the air.

A great many curious experiments might be made on these animals by putting them in media of different degrees of dryness, in currents of air, with hygrometers, &c. &c. to observe how evaporation went on under these

different circumstances, but I have been hitherto prevented from making any by various causes; except one I made at Vienna, in which I placed a large female Edible Frog, (*Rana esculenta*,) fully imbibed with water, under a bell glass resting upon mercury; here it remained near three days without losing any of its weight, at least not a 300th part; yet afterwards on handling it ejected about a 20th part of its own weight of water.

The skin of the Frog-tribe, which is beautifully covered on the inner side with blood vessels, is connected with the body only in a few places; this, one would think, would render the detecting of the lymphatics very easy, yet where the great blood vessels leave the skin and enter the body I could never observe any accompanying lymphatic vessels. It puts on a different appearance in the same animal at different times; that of the Tree-Frog is sometimes smooth and shining, just like the finest kind of green vellum. In this state, if touched with the finger, this receives not the smallest sign of humidity upon it; at other times it is much rougher; if it is then touched it leaves a moisture upon it. It changes likewise its colour according to a variety of cir-

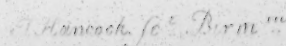
cumstances, which I shall mention when I speak of the characters for determining the species.

Here I must leave this interesting subject, not less convinced than the reader can be, that I have not exhausted it, but only just slightly touched upon it ; yet I expect that it will be thought that I have pointed out new subjects for investigation, and have related some curious facts, and removed some of the first impediments which might have opposed discovery.

PLATE I.

Represents the SALAMANDER, with the mylo-hyoideus and genio-hyoidei muscles cut away.

- a. The superior maxilla.
- b. The inferior maxilla.
- c. The pectoral processes of the scapula separated and turned back.
- d. The skin.
1. The os hyoides.
2. Its cornua.
3. The lateral appendices.
4. The oblique muscles of the os hyoides.
5. The oblique muscles of the lateral appendices.
6. The sterno-hyoidei muscles.
7. One of the sterno-hyoidei lying between the oblique muscles.
8. One of the sterno-hyoidei rising from the os pubis.
9. The upsilon cartilage.
10. The right lung inflated.
11. The liver.
12. The bladder inflated.



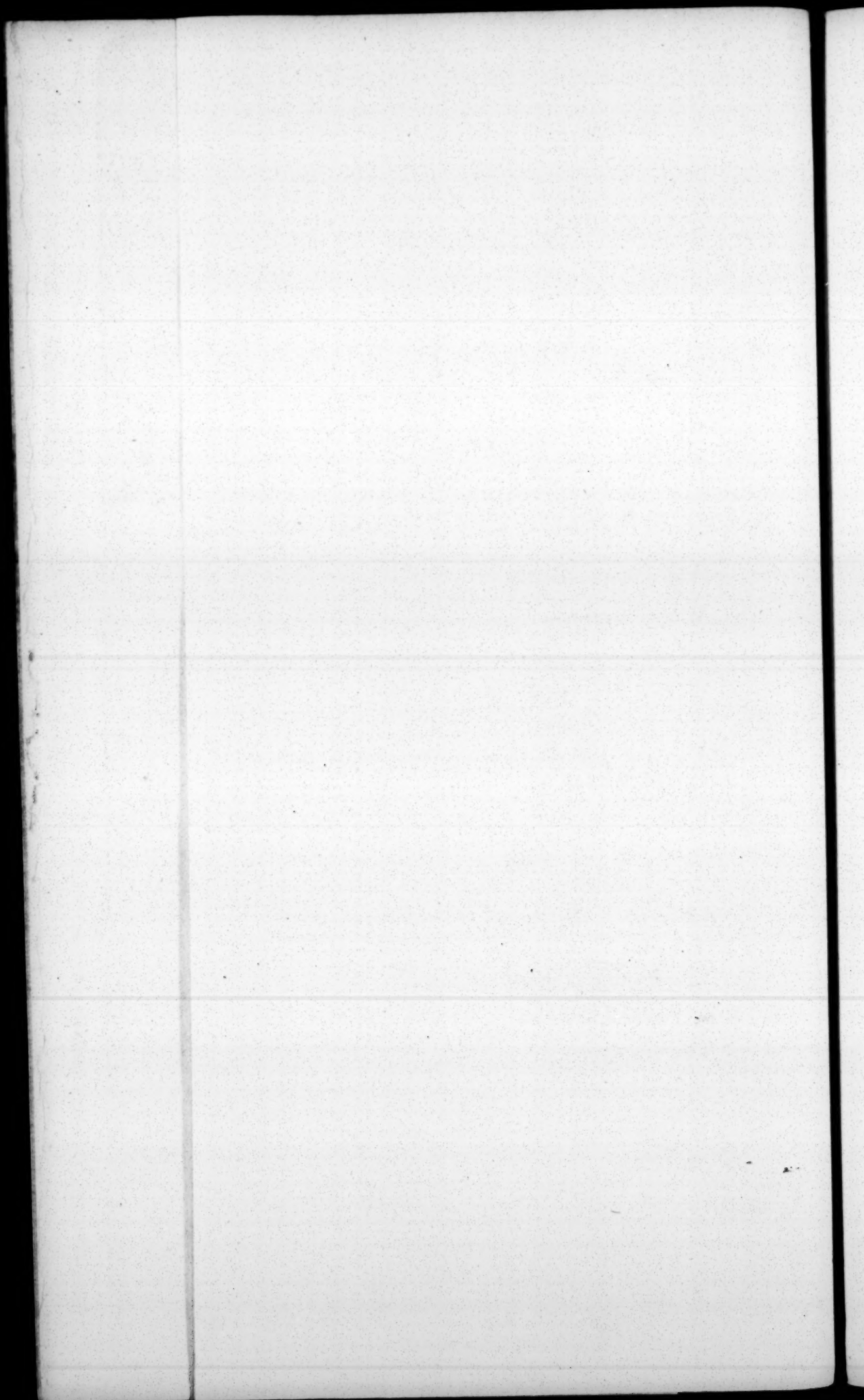


PLATE II.

FIGURE 1.

Represents the lungs &c. of the LACERTA LAGUSTRIS.

1. The inferior maxilla.
2. The os hyoides.
3. Its cornua.
4. The lateral appendices.
5. The lungs inflated.
6. The pectoral processes of the scapula separated and turned back.

FIGURE 2.

Represents the Scapula of the Salamander.

1. The scapula properly so called.
2. Its pectoral process.
3. The bony part.

Tab. 2.

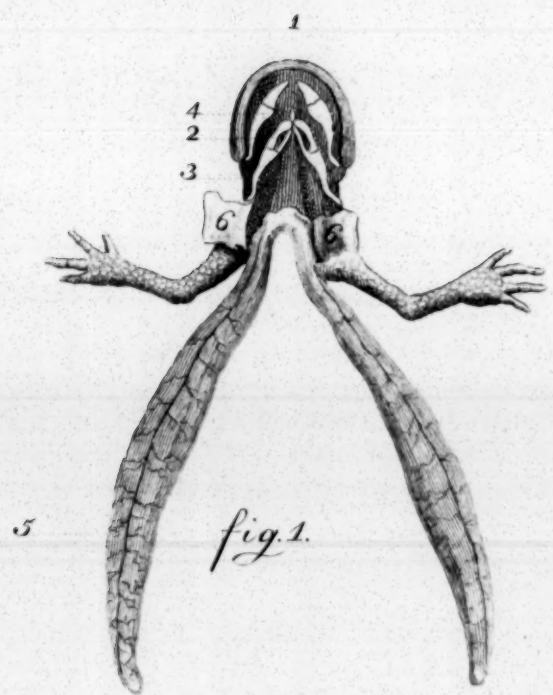


fig. 2.



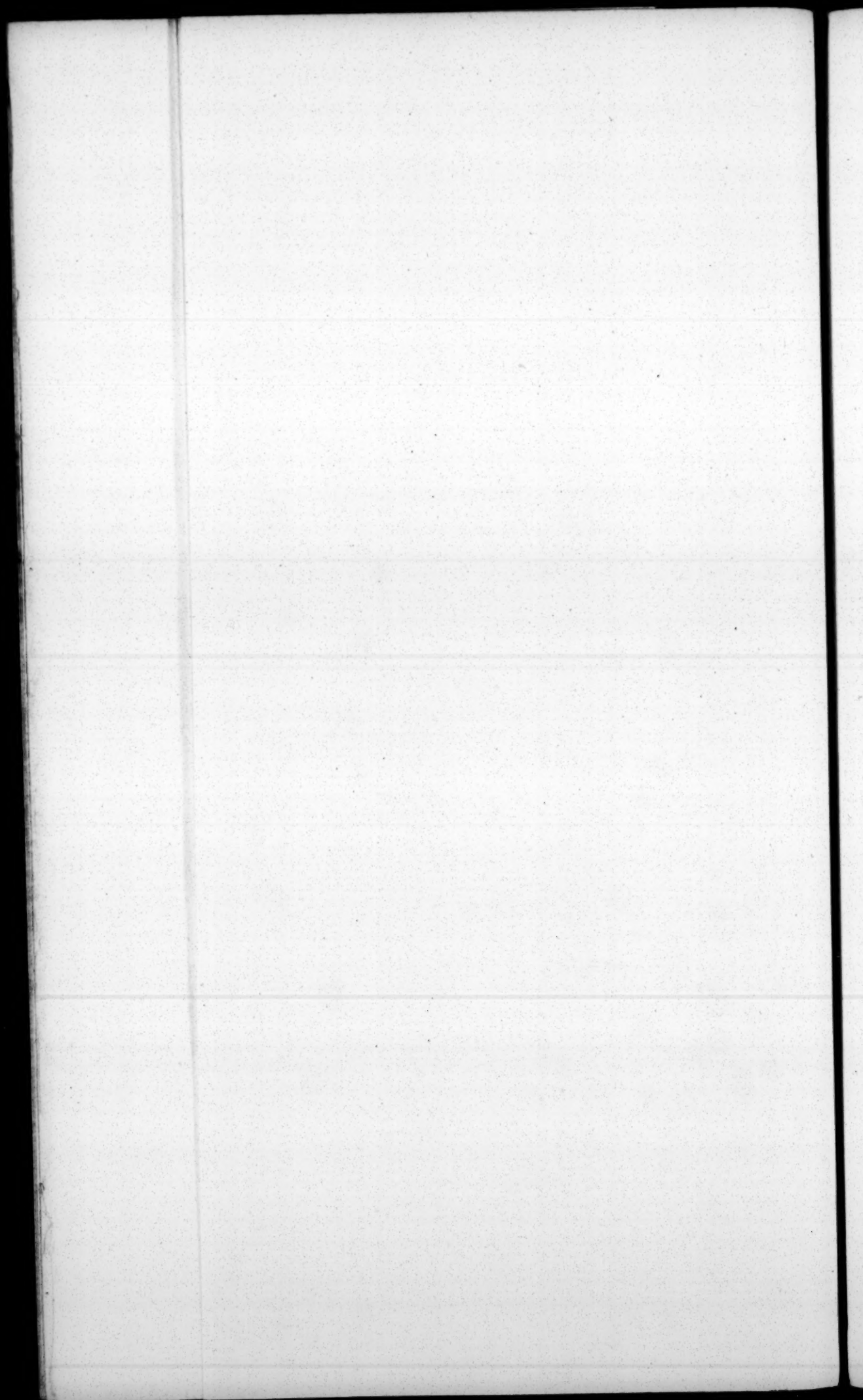
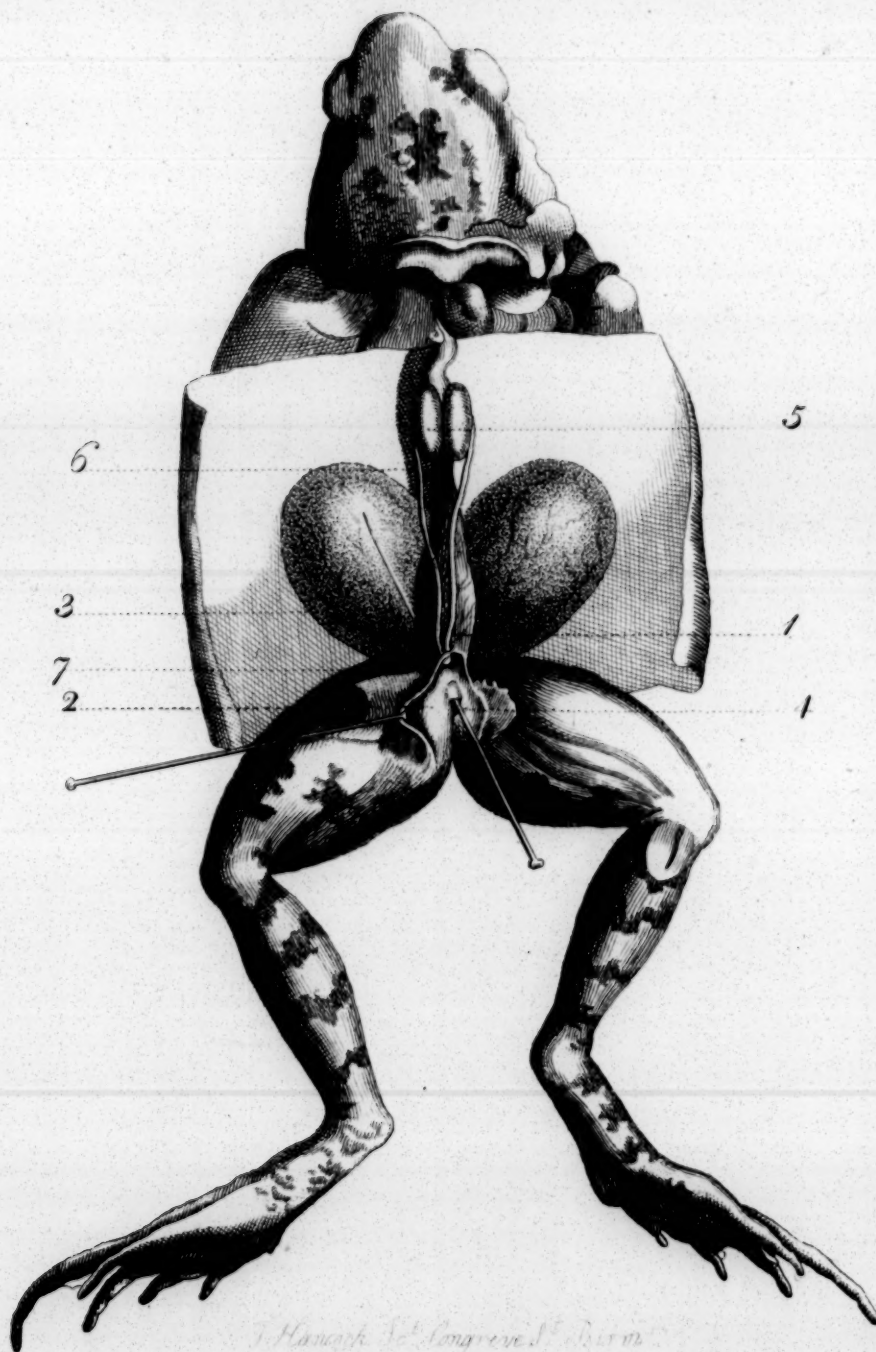


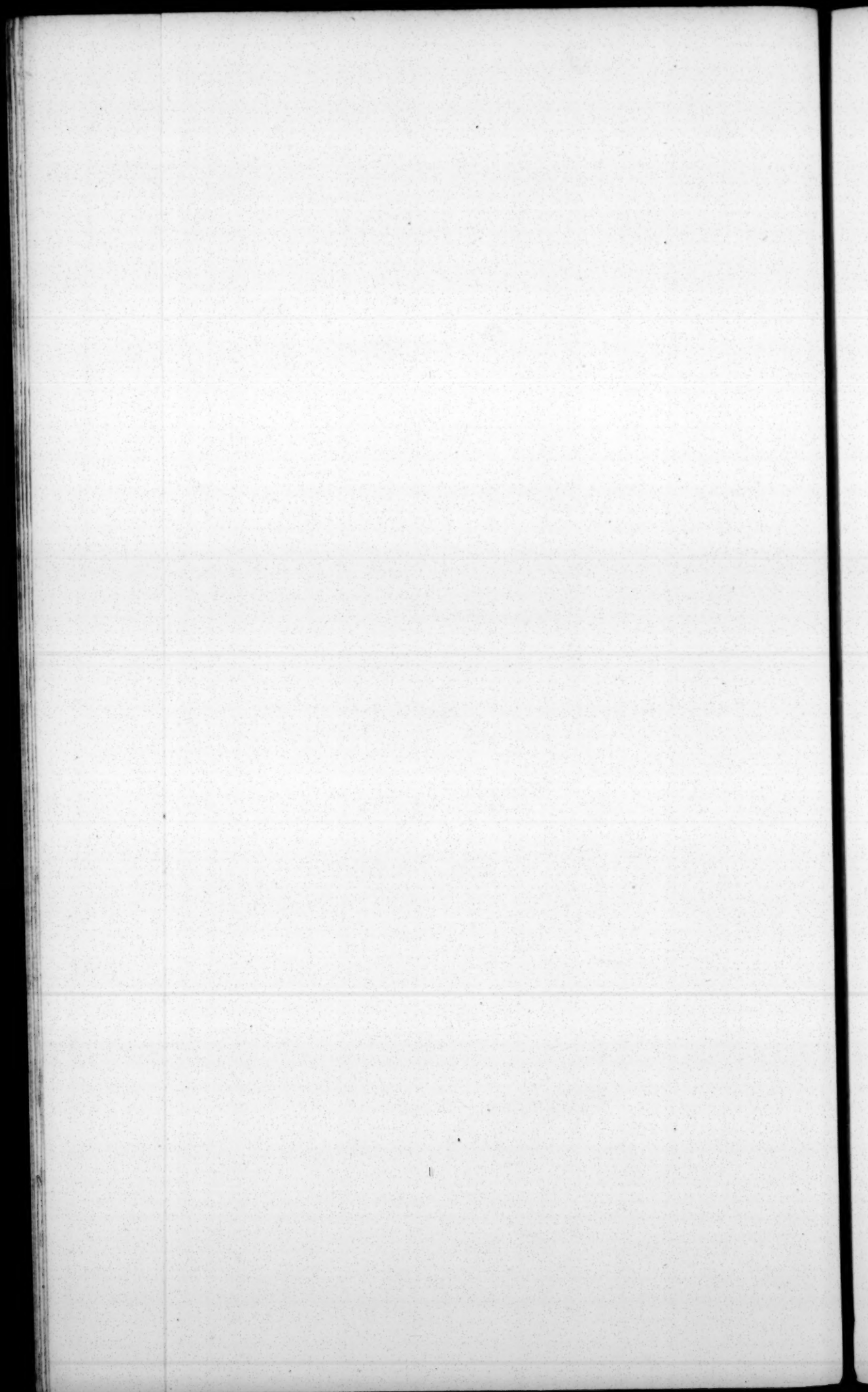
PLATE III.

*Represents the common FROG lying on its belly, with the spine,
os sacrum, &c. cut away.*

1. The intestinum rectum.
2. Where it is cut open.
3. The bladder inflated.
4. The opening from the rectum into the bladder.
5. The kidneys.
6. The ureters.
7. The termination of the ureters in the rectum.

Tab. 3.

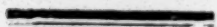




Physiological Observations

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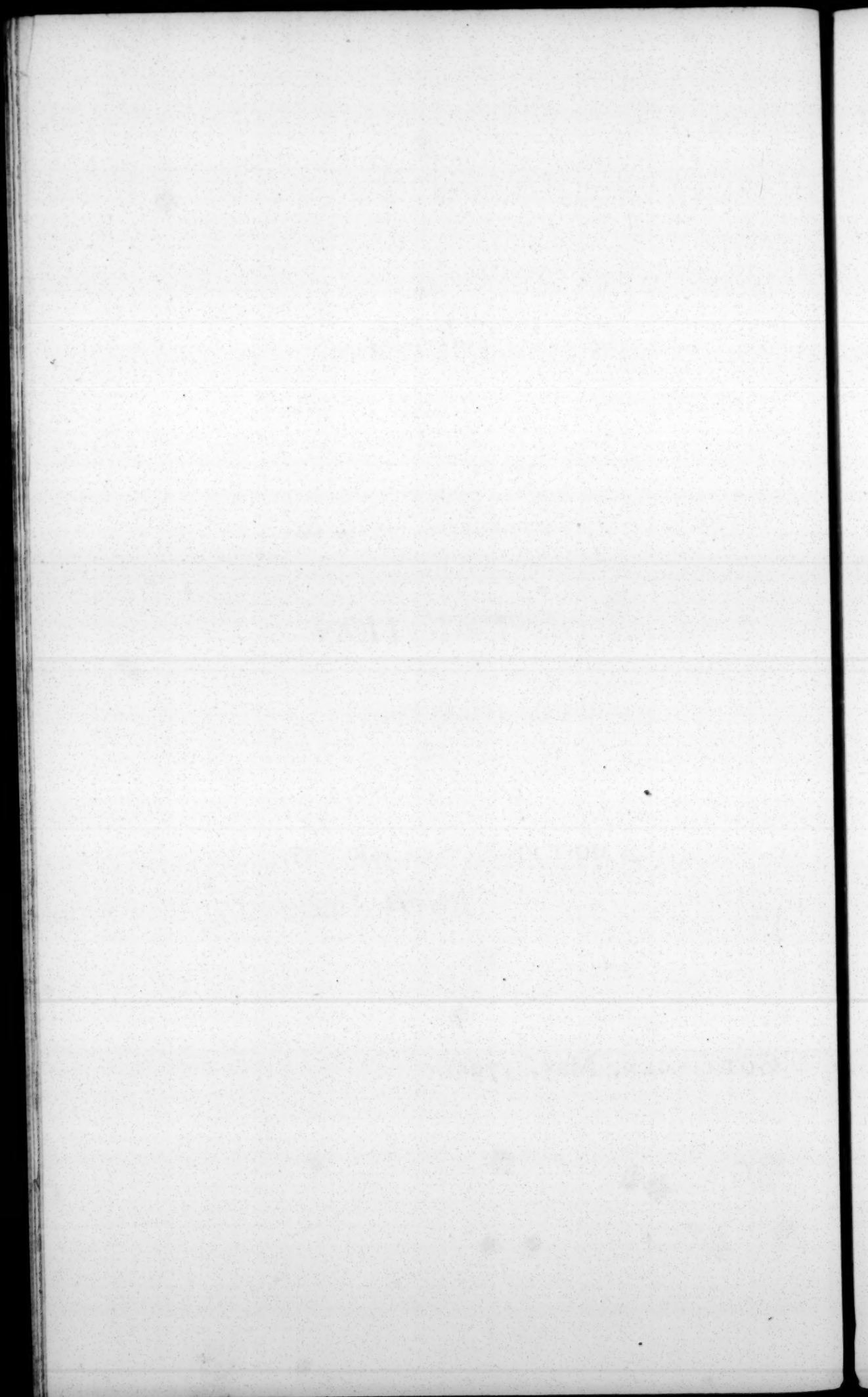
AMPHIBIA.



DISSERTATION THE THIRD,

ON THE

Respiration of the Tortoise.



TO
Dr. WALKER,
PROFESSOR OF NATURAL HISTORY,
IN THE
UNIVERSITY OF EDINBURGH, &c. &c. &c.

THIS DISSERTATION

IS HUMBLY INSCRIBED,
BY HIS FRIEND,
AND MOST RESPECTFUL SERVANT,
Robert Townson.

GÖTTINGEN, May, 1795.

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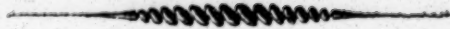
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THE first inspection of the structure of the animals I have lately treated of, the *Ranæ* and *Salamandræ* of *Linneus*, will shew that respiration cannot be performed in them, as it is in man and animals similar to him, the absence of the osseous parts and diaphragm are sufficient to demonstrate this; and though on the records of physiology there are instances of the continuation of respiration after the mobility of the osseous parts had ceased, yet as these were only instances of suffering nature, where the accompanying assistant, the diaphragm, still continued in full energy, physiologists ought, likewise, in examining the structure of the animals I am now to treat of, the Tortoise-tribe, to have suspected that this function was not performed in them as it is in us: yet these hints given by this anomalous structure, have either been neglected or made an improper use of, and the manner of their

respiring remains in the greatest obscurity to the present hour.

Before I proceed to shew the present state of our knowledge on this subject, by giving the opinions of the celebrated anatomists and physiologists who have written upon it, I will just observe, that as the impossibility of respiration being performed in the Frog-tribe, in the usual manner, consists in the absence of the ribs and diaphragm, so here the immobility of the whole bones of the trunk, and absence of the diaphragm, form the insuperable hindrance, and not a deficiency of solid parts as in the preceding; for a modification of the ribs and sternum here envelope the whole animal.

The diaphragm, though said by some to exist, is really wanting. BLASIUS, however, asserts its existence, and describes it thus, “*Diaphragma insigne admodum, oblique a pectoris anteriore inferioreque parte sursum adscendit, lateribus primo, hinc dorso firmiter adhærens; altiore adeoque situm in posticis obtinet, quam in anticis, contra ac in homine, canibus bobus aliisque animalibus observamus, ubi anteriora sublimem majis locum habent posterioribus. Membranosum hoc to-*

tum notatur, similiter ac in avibus variis deprehendimus, nullis fibris carneis manifeste gaudens. Distinguit equidem thoracem a ventre inferiore, ast non ut in animalibus aliis: Pulmones enim cum hic sese in hoc magis, quam illo ventre exhibeant magne parte, diaphragmate haud includuntur, imo vix aliqua parte. Extendit se supra hepar partesque alias ipsi adsitas, usque ad vesicam urinariam cui valide adeo unitur tota superficie superiore ut non nisi magno artificio seperari queat. Superius pericardio jungitur." But I am convinced he has taken the peritonæum for it. I have sought for it in vain, as well as other zootomists: neither Gotwald nor Wallbaum has observed it, and the French academicians who dissected one near five feet long, say, that "la tortue a non seulement son ecaille, qui lui tient lieu de thorax, absolument immobile, mais nous ne lui avons trouvé *n'y de diaphragme*, *n'y d'autres parties* qui puissent supplier a ce mouvement."

This deficiency of the requisite mechanism for respiration, has led some physiologists to explain this important function upon principles inconsistent with sound physiology, analogy, or experience. Perault attributes the

expansion of the lungs, and consequent inspiration to the elasticity of the membranes forming their cells ; and the expiration to the compression of muscles, of which, he says, these animals have plenty, “ apparemment,” he says, “ il est necessaire de supposer que l’inspiration se fait par le ressort des ligamens durs & fermes qui composent les mailles qui ont été decrites : ensorteque, lorsque les muscles qui peuvent comprimer le poumon viennent à se relacher, les ligamens s’étendent & elargissant les ouvertures de toutes les vessies, augmentent la capacité de tout le poumon.”

VARNIER boldly asserted that the whole process of respiration, both expiration as well as inspiration, was effected by the lungs themselves alone, by the means of their muscular texture ; as a muscular net work surrounded them, by which means they could respire by the alternate dilatation and contraction of the vesicles, without the aid of the other instruments of respiration. He says,* “ Je parvins à me démontrer à moi-même que le poumon de la tortue étoit entouré d’un réseau musculaire que par ce moyen il étoit

* In the *Memoires de la Société de Médecine*.

parfaitement irritable, quil avoit une action propre, independente des autres agens de la respiration & quil pouvoit inspirer par lui meme ;” and soon after adds, “ le muscle du poumon de la tortue qui produit un mouvement convulsive,” and then says that, “ dans la tortue le poumon est cellulaire ; les cellules se correspondent comme dans la grenouille ; le muscle enveloppe toute la mafse, & en se contractant la remue toute entiere ;” and concludes his memoire by saying, “ le poumon est un organ actif ; quil est le premier & le principal agent de la respiration, & que cette fonction depend *comme dans les amphibies, de la dilatation & contraction alternative des vessicules* qui determinent alternativement la contraction des muscles inspireurs & expirateurs, & cela independamment de la volonte.”—Admitting the lungs to possess this muscular texture, which could not be perceived by Haller, and the best anatomists, they would still be ill adapted to inflate by their own power.

We learn through the transactions of the royal academy of Paris, * that it was the

* L'Histoire de l'Academie pour, 1699. page 36.

opinion of Monsieur Sauvry, that they breathed only in walking. “ La tortue est enfermée entre deux écailles immobiles, & elles n’a d’ailleurs aucun diaphragme qui puisse servir à une compression alternative des poumons. Dans cette difficulté d’expliquer sa respiration, Monsieur Sauvry s’est avisé d’en rapporter la cause au mouvement du marcher ; quand la tortue est en repos, sa tête & ses pies sont retirés sous l’Ecaille supérieure, & la peau qui l’enveloppe entièrement est plissée, mais quand l’animal marche, il pousse au de hors sa tête & ses pies ; sa peau s’étend puisqu’elle est tirée par ces parties, & par conséquent elle forme intérieurement un plus grand espace, & c’est dans cet espace vuide que l’air extérieur est obligé d’entrer.” This explanation, which is very anomalous with every thing we know of this function in other animals, I put to the test of the following experiments, which proved it erroneous.

I took the *Testudo orbicularis* in its contracted state, and wrapt it up in paper, binding it all round with bandages so fast, that the *testa* and *sternum* were brought so near before, as not to admit the exit of the head : I then made an aperture in the paper opposite

to its nose, and thus deprived of every motion, I placed it before the flame of a candle, yet I found not only that it blew the flame, but sometimes so strongly as nearly to extinguish it. This experiment, though conclusive against the opinion of Sauvry, I strengthened by another: in this I kept the legs out, binding them very firmly under the sternum, the head being contracted as before, yet I still observed that it breathed, and as in the former experiment, sometimes with great force. The respiration, therefore, of the Tortoise has no more connection with its other motions than that of other animals.

But Morgagni, who was, as I have mentioned in the second dissertation, acquainted with the manner of respiring in Frogs, which I have given in detail, supposes that the Tortoise respire in the same manner; for speaking of the Frog, he says, * “*Inspiratio autem iis instrumentis per quæ inferior buccæ pars amplificata, & mox contracta aerem in pulmones compellit,*” and then adds, “*quin imo id ipsum, dum fluvialem*

* Morgagni *adversaria Anatomica* V. animad. 29.

quandam testudinem vivam inciderem, observavi, invenique, totam eam partem quæ intra cavitatem mandibulæ inferioris est, multum posse extrorsum curvari ut hinc aer immitti posset, pulmones vero fibrarum rete firmari, ut hinc aer vicissim posset remitti."

Notwithstanding the high reputation of Morgagni, I must dissent from the opinion of the Tortoise respiring like the Frog. I will not say that none of the genus do respire in this manner, as I have had no opportunity of examining any of the Turtles. I wish to be understood, as speaking of the *Testudo orbicularis*, my observations having chiefly been confined to this species, though I think I may say the same of the *græca* and *palustris*. Yet the opinion of this celebrated man is supported by Coiter and Varnier saying, that, after the sternum is taken off, and the lungs are laid bare, the animal can still inflate them. But if after the sternum was taken off, the peritonæum cut through, and the lungs laid bare, these appeared to Coiter and Varnier to inflate, this might not have proceeded from any power residing in the lungs themselves, nor from any air being impelled into them by the muscles of the

throat; but by the parts in contact with them, as the neck before, and the muscles behind, (which I shall soon describe,) shortening them, in which case they would appear more distended, though the quantity of air within was not encreased.

The Tortoises which I opened I never observed to inflate their lungs as the Frogs do; nor did the anatomists mentioned by Valentini* observe it, for they say, “*Pulmones enim depresi remanebant, nec inflabuntur ab illa aeris attractione, quod fieri potuisset tamen ab animali adhuc vivente licet capite truncato, quod ego subito, antequam aperiri curarem, abscindi iusseram.*” Yet adds, “*Vitales autem hæc testudo actiones habuit horæ spatio absque corde sed et absque capite: nam pedes movit ad tactum nostrum et sine eodem quoque retraxit.*”

These are the opinions of the older anatomists; and amongst the moderns I know of none who have said any thing on this subject. Being dissatisfied with them, I entered into the investigation by actual observa-

* Valentini *Amphitheatrum Zootomicum*, p. 229.

tion, and opened one for this purpose. The sternum being taken off with great care, the periosteum presents itself as a strong white membrane like parchment; when I had cut through this, I found many muscles inserted into it, particularly over the *scapulæ* and *os pubis*, which in the contracted state of the animal are not far asunder. Just above the *os pubis*, it is connected to the peritonæum; by this means these bones, with their muscles, are enclosed as in a bag, having the peritonæum beneath, and the periosteum above; the *scapulæ* and their connected bones and muscles are enclosed in the same manner.

The *peritonæum* being cut through, and the intestinal canal liver, &c. removed, the lungs, consisting of two lobes, are seen covering nearly the whole of the *testa*; they are cellular as in the Frog, and consist of two lobes, one on each side of the *spina dorsi*, each of which is subdivided into four or five indistinct lobules. The cellular texture of these is not uniform; the cells of the middle lobules being the smallest, and those of the last lobule the greatest; this lobule is likewise loose, not being tied down on the sides nor beneath, the rest are tied down to the spine.

My attention was soon called to observe the structure and office of some muscles in the region of the flanks, which I observed often to be in motion, contracting and extending alternately, and though placed by the side of the hind legs, these were not moved by them. Further, they were placed at the end of the last lobule of the lungs, and they appeared to retain their irritability the longest. This was sufficient to lead me to conjecture that these might be the parts, by which respiration in these animals was performed ; and to see them act in their natural position I sawed off, in another Tortoise, that part of the shell which covers them, and I then saw them constantly working. One was now placed nearly in a perpendicular direction, and another, or part of the same, was placed nearer the sternum, lying almost in a horizontal direction. The first in its contraction receded from the *testa* inwards, whilst the latter, in its contraction, observed a contrary direction.

When I attributed to them the office of expirator and inspirator muscles, which I supposed them to perform, I was embarrassed, because I could not conceive how a muscle could be a constrictor with its convex side ;

yet, when the expirator, by contracting, had receded from the shell inwards, it appeared, when viewed from without to be concave. But this difficulty ceased as soon as I had opened the animal and dissected the parts, for I then found the following admirable contrivance of nature.

This part is composed of two distinct muscles, with their risings and insertions quite different, yet firmly connected in the middle by cellular membrane. The first rises from the testa near the spina dorsi (see pl. 2, let. B.), and is inserted into the peritonæum; this is the constrictor of the lungs, or the muscle of expiration. The other is nearly spread over the whole cavity, between the upper and under shell, where the hind legs are drawn in during the contracted state of the animal, being inserted into the margin of the testa above, and the margin of the sternum below, (see tab. 1, let. *a*.)

The places of insertion of these muscles, and their connection in the middle being known, there is then no difficulty in explaining why the muscle, while acting as a constrictor, appeared concave, as it was only the inspirator brought into that position by its an-

tagonist ; nor any difficulty in conceiving how they carry on the function of respiration ; for the expirator being connected, as I have already said, to the testa below,* and to the peritonæum above, envelopes in a manner the last moveable lobule of the lungs ; when therefore it contracts, it comprefses this part of the lungs, and by that means expels the air ; then ceasing to act, the other contracts and draws the former with it, thus a vacuum is formed, into which the air rushes as in the respiration of those animals which have a thorax.

To prove that this explanation was well founded, and that the motions of these muscles were really those of respiration, I made the following experiment. I fastened on the nose of a Tortoise a little valve made of white paper which covered the nostrils, and with the assistance of a friend, I watched the motions of the soft parts lying within the hollow where the hind legs came out, and I found that these motions perfectly corres-

* The animal is supposed to be lying on its back for dissection.

ponded with the motions of the valve, which was put into motion by the expirations and inspirations of the animal.

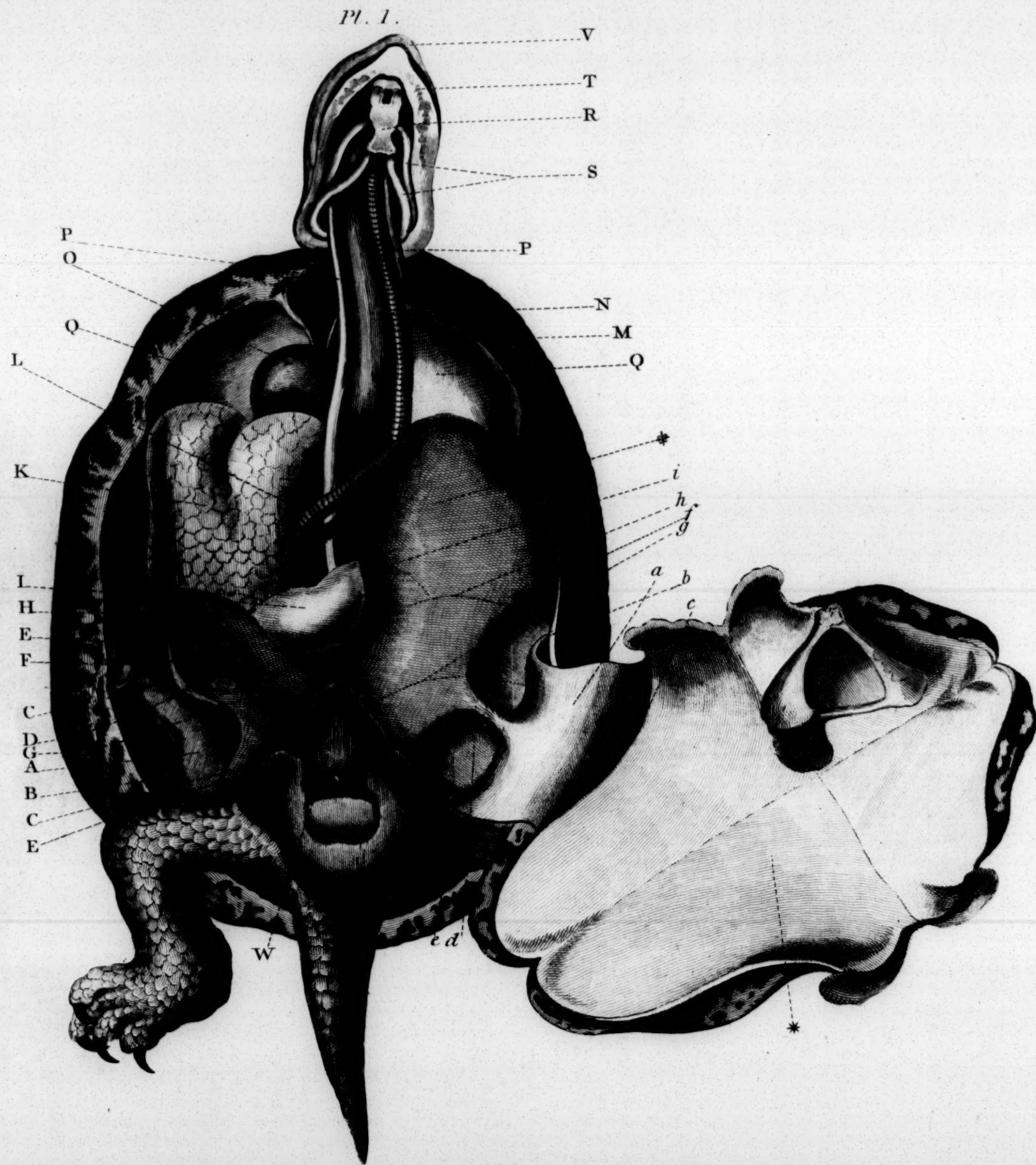
In this manner I conceive respiration to be carried on in the Tortoise, without, however, meaning to extend this explanation to the whole of the genus *Testudo*; some families of which I have never yet had an opportunity to examine. These animals will therefore materially differ from those of the two preceding families in the mode of respiring; the air in them being driven into the lungs by the muscles of the throat, which act like a pair of bellows; whilst in these it is performed by the lungs following the motions of their containing parts, and they will therefore differ from the animals having a thorax chiefly in the form and situation of the parts.

Respiration is not, I think, the only office of the muscles which I have just described; they are closely connected to the bladder, and to them I think this animal is indebted for the power it possesses of sucking in water by the anus, as I mentioned in my last dissertation; but this investigation I must leave to another time.

PLATE I.

Represents a TORTOISE (Testudo orbicularis) on its back.

- * The sternum turned back.
- ✱ The peritonæum covering the left lobe of the lungs.
- A. The muscle of inspiration nearly in its natural situation, still connected to the testa, but separated from the sternum.
- B. The place of its insertion in the testa.
- C. Where it was connected to the sternum.
- a. The same muscle still connected to the testa and sternum, but turned back.
- b. When it is inserted in the testa.
- c. Where it is inserted in the sternum.
- D.d. The cellular membrane by which it is united to the muscle of expiration.
- E. e. The muscle of expiration.
- F. f. Where it arises from the peritonæum.
- G. g. The dotted line shews where the peritonæum ceases to be connected to the bladder.
- H. h. The out-line of the bladder when inflated.
- I. The middle bladder not covered by the peritonæum.
- i. The out-line of it where covered by the peritonæum.
- K. The right lobe of the lungs.
- L. One of the bronchia.
- M. The aspera arteria.
- N. The neck.
- O. The neck curved as when brought under the testa.
- P. Two of the muscles which draw the neck under the testa.
- Q. The inside of the testa where the fore legs have been
- R. The os hyoides. [cut away.]
- S. Its horns.
- T. The inferior maxilla.
- V. The superior maxilla.
- W. The os pubis.



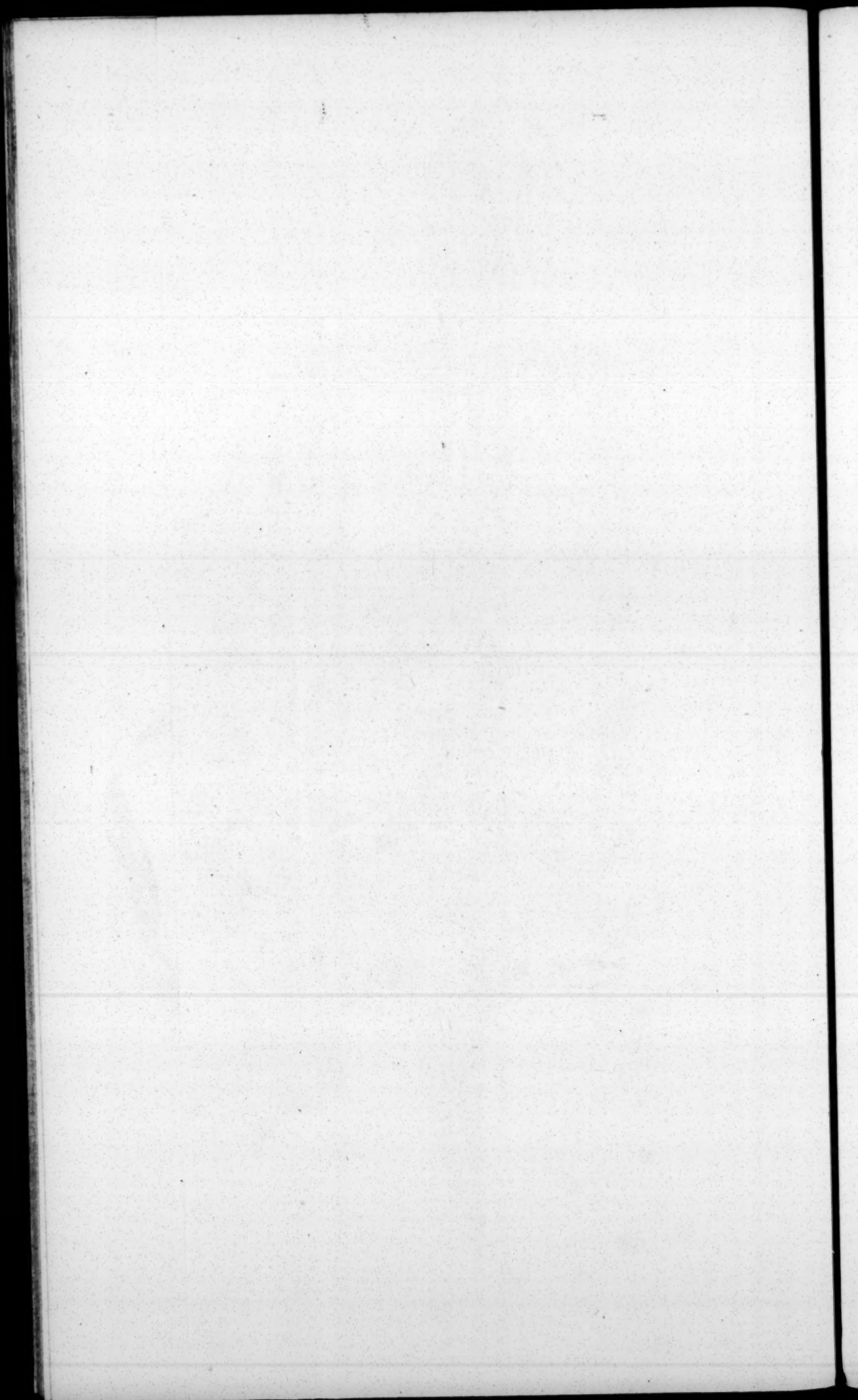
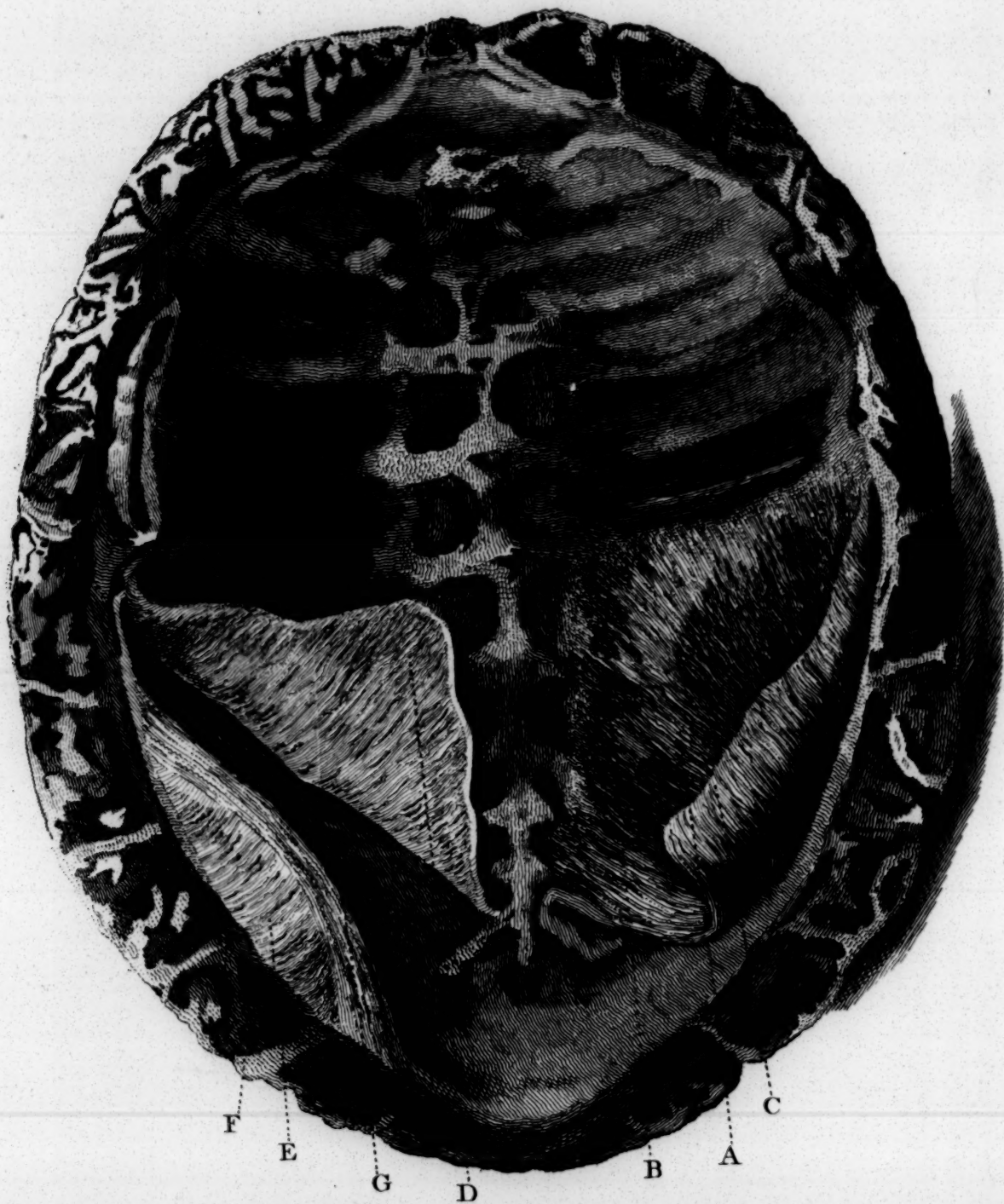


PLATE II.

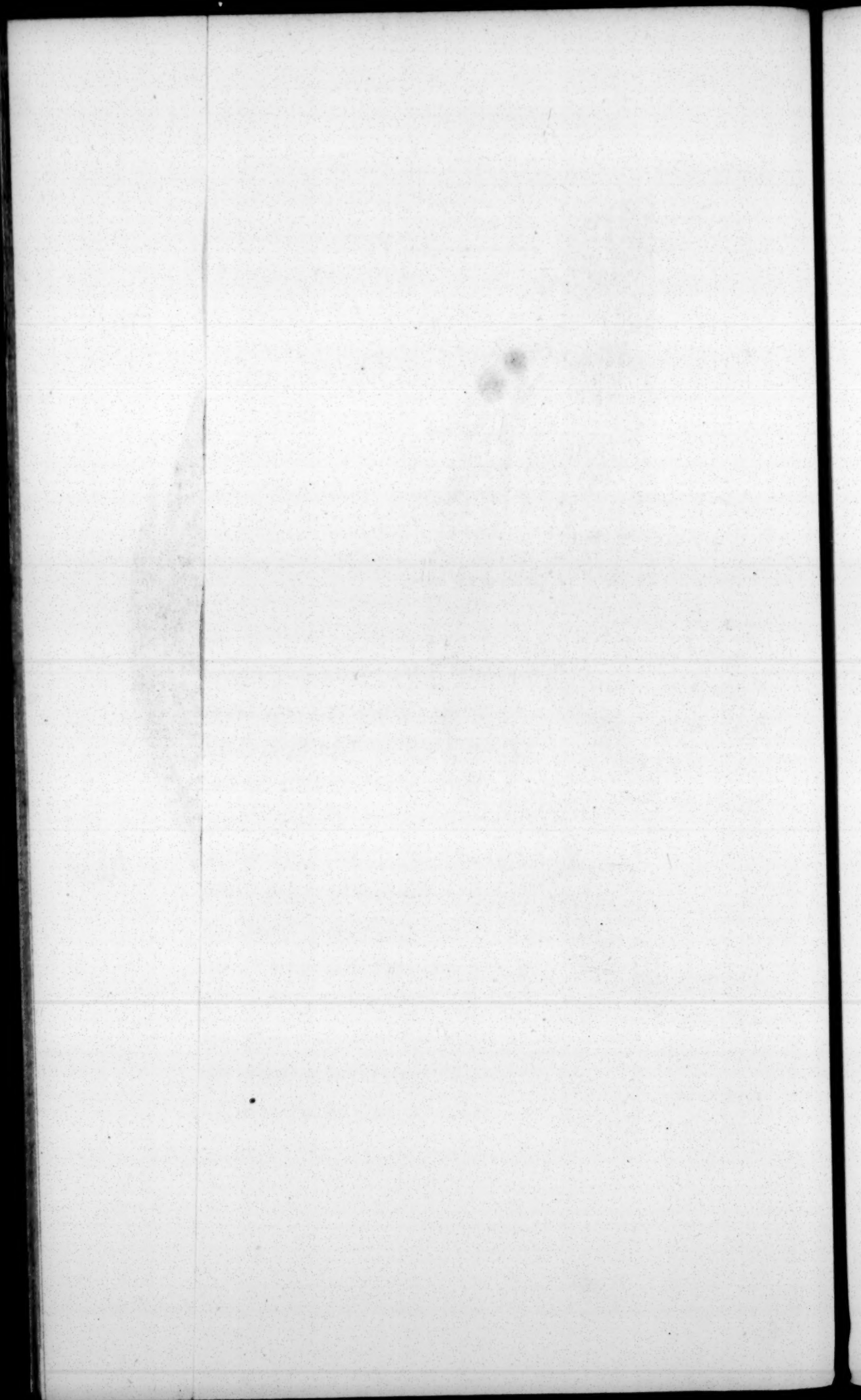
Represents the TESTA, or upper shell of the TORTOISE, (Testudo orbicularis) with the muscles of respiration.

- A. The muscle of expiration.
- B. Its insertion in the testa near the spina dorsi.
- C. Termination of the muscular fibres where they were connected to the peritonæum.
- D. The same muscle turned back.
- E. The muscle of inspiration.
- F. Its insertion in the margin of the testa.
- G. Where it was inserted in the margin of the sternum.



Barlow sculp

back of p. 101.



Miscellaneous Remarks

ON THE

AMPHIBIA.

WHEN I wrote the preceding papers, I expected I should, at some future period, have had both time and inclination to extend my enquiries further. I was then warm in the pursuit, and still saw unbeaten fields lying before me.

Five years have since elapsed, and now other studies and pursuits engage my time, so that I consider myself as having given up these researches. Yet by no means under the idea of having exhausted the subject, for, on the contrary, I think that those who will resume these enquiries, will be recompensed by adequate discoveries.

Having found amongst my papers some miscellaneous remarks, made at the same time as those which have been the subject of the preceding papers; though trifling, I now lay them before the public.

To different animals different means are given of resisting the extremes of heat and cold, which adapts them for exerting a more general usefulness through a greater extent of climate. In some it principally resides in the clothing nature has bestowed upon them; in others it is the result of a peculiar internal organization. In the latter, amongst which are the animals now under consideration, their security arises from the lower state of animal life to which they may be reduced without any risk to life or injury to their organization. Life, in these, may be reduced to a latent state, and continue to exist without any of the usual pabula, till external causes, with their constant concomitants the requisites of life, revive the latent spark.

Whilst I was engaged at Göttingen in the preceding enquiries, I collected a great many Frogs, I think about eighty, chiefly the *Rana temporaria*. I kept them in a cellar, in a box, in which I placed a bowl of water. After

the hard frost had set in I visited them, and found seven or eight dead; these were by themselves; those which had crept together into a heap were alive. Their motions on being stirred were, indeed, very languid. Many of them had ice between the skin and flesh, which, in these animals, as I have before stated, is only connected in a few places, and water thus situated I have often found on dissecting them. I placed a very sensible thermometer amongst them, which indicated only 2 degrees under the freezing point of Reaumur. I brought the dead, and three live Frogs out of the cellar. The dead I first placed in a room a little warmer than the freezing point, and then in a warm room, but they never shewed any signs of life. Of the three that were alive I put two in a passage which varied from 8 to 10 degrees under 0 of Reaumur, according as the street door was open or shut. The other, after it had been in the passage a minute or two, and was still able to move its limbs, I placed in my warm study. This soon recovered its activity, and lived. The other two, which I had left in the passage not above an hour, were totally deprived of the little motion they had previously pos-

sessed. One, on being removed to my study, after some time shewed some feeble signs of life, but soon died ; the other continued perfectly motionless and dead.

Three or four days after this, I again visited the cellar. I then found all the frogs frozen together. Some that were undermost, though glewed to the others, had their fore-legs pliant and could feebly move them. I brought the box with its contents into a room about 2 or 3 degrees of Reaumur above the freezing point. Several shewed signs of life, but only ten recovered, and most of those died within a week : such was the havock done by the cold. Yet this was but very moderate ; never exceeding three degrees of Reaumur under 0, or the point of congelation. For the following morning, when the frost had had one day more to penetrate into the cellar, though the thermometer hung out at my window was 19 degrees under 0, yet in the cellar it was only 3 under 0 ; and 19 or 20 degrees, which indeed is very great, was the severest cold we had then had at Göttingen in the severe frost of 1794.

Hence it appears that these animals are unable both to keep off or to support the mo-

derate degrees of cold to which most hot-blooded animals are annually exposed, and which they, by their cloathing and faculty of generating heat, are able to resist; and they could not exist in many of the climates of which they are numerous and useful inhabitants, had they not been instructed by nature to conceal themselves in ponds and ditches, where the temperature of the earth, which in all the temperate climates is considerably above the freezing point, moderates the rigour of the atmospheric cold.

I have fished these animals out from under the ice in a very languid state, and what is remarkable, I have seen them under the ice in this languid state, carrying on their amours, as if their first sensation of returning life, on the approach of spring, was animal desire.

It is a well known fact that the thumbs of the males of the Frog-tribe become very rough and black like *chagrin* in the season of their amours, and it is equally well known that this is to assist them in adhering to their females, but I know not whether the singular brawny fore legs of the males have been noticed. In general the females in the Frog-tribe are larger

than their males, and their hind legs are in proportion to their bodies; yet the fore-legs of the males, and particularly of the *Rana temporaria*, are very considerably bigger than the females. It is obvious that this is to enable them to adhere to their mates, nor indeed will it seem to be an unnecessary gift if we attend to the continued force which they exert in their embraces: and adhesion to the female is not the only reason of this pressure. I have observed, on killing a male Frog by a blow on the head, that the fore-legs contracted with spasmodic violence, in the same direction as in the act of their amours, whilst no similar contraction took place in the female when treated in the same manner.

In the selection of characters for the distinguishing of natural objects, naturalists are right to employ those which are most obvious, in preference to those which require microscopic or anatomical investigation; yet will these often indicate natural affinities, which are never to be omitted in the study of natural history.

In the bony structure of the Frog-tribe I have observed considerable difference, par-

ticularly in the anterior part of the thorax. The *Bufones*, or Toad-tribe, the first family of Linneus, have no superior or inferior os ensiforme, but the clavicular bones lap over each other in the middle, are loose and play upon each other. This structure is most probably given them as being animals that move by walking.

The *Ranae* proprie dictae, the common Frog-tribe have both a superior and inferior ensiform bone, and their clavicles are not loose in the middle but fixed; these leap rather than walk.

The *Hylae* or Tree-Frog-tribe, of which we have none in our island, have the ensiform bones of the common Frog, with the loose clavicles of the Toad: these both leap, creep, and climb.

In the skeleton of the Lizard-tribe I have observed essential differences in different families; and even the species to be often distinguishable by minuter differences. But as I have had occasion only to examine a few, I should not think my observations on them worth relating were I not now on the subject. The Salamandræ, for instance, as I have already observed, differ from the Ameivæ by

being destitute of ribs. They differ likewise in their scapulæ and clavicles. These in the Salamandræ are of a very singular conformation, they are both but cartilaginous appendices of the os humeri, to which they are immoveably fixed. The Lacerta Salamandra may be distinguished from the L. Lacustris, though of the same family, by the os hyoides and its appendices, which in the former is intirely cartilaginous, in the last osseous; but lest these remarks should appear tediously minute I will terminate them.

I find a difference in the opinions of some celebrated anatomists relative to Serpents having one or two lungs. Thus, Morgagni, in his *Adversaria Anatomica*, 5, animad. 29, differs from Veslingius, who, it seems, asserted he had found them double in the Viper. Morgagni says, num vero haud absimili ratione defendi possit quod de Viperæ pulmone scripsit Veslingius: in eum videlicet “duplici distractam ramo asperam arteriam delabi:” alii viderent; nobis enim, qui multo plures, viperas, quam ranas secuimus, nunquam certe datum duplicem istum ramum videre, cum et ipse viperæ pulmo simplex sit, id est unus

oblongus lobus ex innumeris primum circum circa quasi vesiculis in favi modum apertis, deinde ex una magna continuata vesica manifestissime constructus.

And Mr. Blumenbach supports the opinion of Morgagni in his *Spec. Physiol. Compar. inter Animant. Cal. & frig. Sang.* He says, page 76, “Unicum denique saccum in totum cavum et insignis magnitudinis constituit pulmo natricis: et ut ex aliorum anatomorum consensu patere videtur serpentium in universum omnium.”

This difference of opinion may probably have arisen from Veslingius, and others of the same opinion, mistaking some Serpent for a Viper, which really was not one, and anatomists are not always naturalists. I have examined but few, but believe the lungs of most serpents to be simple; yet in the *Anguis fragilis*, I found them double; whether they are double in the whole genus of *Anguis*, which has an external affinity with the *Sepes* or *Ameivæ* of the genus *Lacerta*, in which they are double, must be determined by observation.

When the species of any genus of natural bodies are numerous, it is requisite that it

should be subdivided into tribes or families; this greatly facilitates investigation, and obviates the necessity of creating new genera. I find the genus Testudo, in Professor Gmelin's edition of Linneus, divided into three families—viz. into the *Marinae*, *pedibus pinniformibus*; the *Fluviatiles*, *pedibus palmatis testa cum sterno membrana juncta*, and the *Terrestres*, *pedibus clavatis unguiculatis, testa commissuris osseis cum sterno juncta*.

These are very natural divisions and accompanied by proper characteristics. But from a Tortoise I received from Glasgow, and which I believe came from Jamaica, I think the genus must be divided into four families; for this, which probably was the *palustris*, had the palmated feet of the *Fluviatiles*, with the testa and sternum connected as in the *Terrestres*. This fourth family should be thus characterized: *Pedibus palmatis testa commissuris osseis cum sterno juncta*; and if no more appropriate name occurs to those who have an opportunity of observing their habits, this family may be denominated the *amphibiae*; as probably the union of the structure of the families, the fluviatile and terrestrial, may adapt them to a more amphibious life.

I will terminate these miscellaneous remarks on the amphibia by the following observations. Whilst I was engaged in these inquiries, I kept a considerable number of water lizards in a jar, which I fed from time to time with worms; if they were in the greatest stillness and I dropt in a worm ever so gently, they all immediately began to fight, each attacking its neighbour and seizing it by the foot or tail. This was not a contention for the worm, which often lay for a short time unnoticed, but it originated, rather, in the acuteness of their sense of smell, which immediately informed them of the presence of their food, and in the dullness of their discriminating powers. This is similar to what I have invariably observed in Frogs and Toads, which will suffer their natural food to remain before them untouched, yet seize it instantly on the smallest motion it makes. It was from a knowledge of this instinct that I was able in winter to feed my constant companion and favourite pet, MUSIDORA.

Before the flies, which were her usual food, had disappeared in autumn, I collected a great quantity as provision for winter; when I laid them before her, she

took no notice of them, but the moment I moved them with my breath she sprung and ate them. Once when flies were scarce, I cut some flesh of a Tortoise into small pieces, and moved them by the same means, she seized them, but instantly rejected them from her tongue. After I had obtained her confidence, she ate from my fingers dead as well as living flies.

Frogs will fly at the moving shadow of any small object, and both Frogs and Toads will soon become so tame as to sit on one's hand and be carried from one side of the room to the other, to catch the flies as they settle on the wall. At Göttingen, I made them my guards for keeping these troublesome creatures from my desert of fruit, and they acquitted themselves to my satisfaction. I have seen the small Tree-Frogs eat humble bees, not indeed without a battle; they are in general obliged to reject them, being incommoded by their stings and hairy roughness; but at each attempt the bee is further covered with the viscid matter from their tongue, and is then easily swallowed.

Nothing appears more awkward and ludicrous than a Frog engaged with a large

worm or little snake ; for nature seems to have put a restraint upon their voracity, by forming them very inapt to seize and hold their larger prey. One of my largest Frogs, whether the *Rana temporaria*, or *esculenta*, I forget, swallowed in my presence an *Anguis fragilis* near a span long, which, in its struggles, frequently got half its body out again ; when completely swallowed, its contortions were very visible in the flaccid sides of the conqueror.

I am exceedingly sorry to terminate these remarks by informing Musidora's friends (for she had many) that she is no more. She sickened soon after she reached Great Britain, and died in the night of the 25th of June, 1794 ; probably her death was occasioned by the sea air during her voyage from Hamburgh to Edinburgh.

ON THE

Structure of the Bill of the Cross-Beak.

The Loxia curvirostra.

TO read the works of celebrated men merely with a view to detract from their merits, and to hold up their trifling errors as samples of the general tenor of their writings, is invidious and unjust. But when vanity and an unreasonable desire of popular applause, lead the man of science to quit the cool sagacious research and the simple language becoming the dignity of his pursuit, and, disregarding the approbation of the just distributors of fame, courts that of the multitude, and in brilliant diction passes off his hasty speculations for the result of inquiry, I think his vain reasoning may be held up to derision, and his errors be condemned to literary punishment. I trust therefore, in elucidating the following curi-

ous subject, which the French Pliny has treated in a very careless manner, not to be censured as a literary detractor.

A few years ago, when I was at Göttingen, I kept several Cross-beaks, which, by kind treatment, soon becoming tame, I suffered to be loose in my study. I had thus constant opportunities of observing them, and as often of admiring their docility and sagacity ; but the singular structure of their bills chiefly engaged my attention. The bills of some of the feathered tribes are so irregular in their form, and so preposterous in their size, that one would almost think that nature had not shewn her usual kindness towards them, but had, in derision, instead of giving them a useful instrument of nutrition and defence, loaded them with an awkward and unseemly protuberance, to make them the scorn of their companions. Yet those who have attentively considered the structure of animals, and their offices in the great economy of nature, though they may have been often struck with some apparent irregularity or defect, yet will have found, upon attentive observation, that they are well adapted to their destinations.

Though the bill of the Cross-beak does not excite the idea of preposterous singularity, like that of the Rhamphastros and the Buceros, and some others, yet it is not less singular. It is unique, for it is the only one in which the two maxillæ or mandibules, instead of lying straight, the one upon the other like the fangs of a pair of pincers, pass for a considerable part of their length on the side of each other like the blades of a pair of scissors: the upper maxilla or mandible towards the point being inclined to one side, and the inferior inclined to the other.

This singular structure indicates a peculiar destination; but it is not that of cutting off twigs, as some have supposed from their similarity with scissors, but for procuring their food by the following address. The great pine forests, such as that of the Hartze in Germany, are the natural places of residence of the Cross-beaks, and the seeds of the cones of these trees their food, and it is to pull out the seeds from between the squamæ, or scales of the cones, that this structure is given them. Their mode of operation is thus: they first fix themselves across the cone, then bring the points of the maxillæ from their crossed or

lateral position, to be immediately over each other. In this reduced compass, they insinuate their beaks between the scales, and then opening them, but not in the usual manner but by drawing the inferior maxilla side-ways, force open the scales or squamæ; they then bring the points of the maxillæ over each other, and pick out the seed in the same manner as if the bill had the usual form.

The degree of this lateral force is surprising, and they are fond of exercising it for mere amusement; they are therefore not a little mischievous. My pets would often come to my table, whilst I was writing, and carry off my pencils, little chip boxes in which I occasionally kept insects, and other similar objects, and tear them to pieces in a minute. Their mode of operation is by first pecking a little hole, in this they insert their bill and then split or tear the object by the lateral force. When I treated them, as I often did, with almonds in their shells, they got at the kernel in the same manner; first pecking a hole in the shell, and then enlarging it by wrenching off pieces by the lateral force.

Notwithstanding Mr. Buffon's assertion to the contrary, they can pick up and eat the smallest seeds, such as poppy seed ; with this indeed the dealers in Birds in Germany commonly feed them, and they shell or husk hemp and similar seeds like other Birds ; so well contrived and useful is this singular beak. I ought now to give the anatomy of it, and I wish it were in my power ; but on the muscles, by which the motions I have spoken of are performed, I find scarce any memorandums in my port folio ; and I perceive I can do little more than give the bony structure. This is remarkable. The two sides of the inferior maxilla are not equal and similar, but that on the side to which the mandibule inclines is the straightest ; the opposite side being rather convex. The sides vary at the condyles, but in so small a degree that I can hardly point out the difference. The socket which receives the rounded process of the upper jaw is evidently less deep on the straight side, this is to permit the partial dislocation which always takes place when the lateral force is used ; for then the termination of this side of the jaw is drawn considerably backward, whilst that on the other side keeps its place ; this is very sensible in the living Bird.

Of the muscles by which these motions are performed I can only say, that there are none additional or extraordinary for the purpose ; but the temporal, and the digastric which is connected to the end of the jaw, are rather stronger on the straight side. Both of these may have considerable power in drawing this side of the maxilla backward, and laterally, as well as downwards; and most of the muscles that move the lower jaw towards the upper, seem to be so situated, as, by the relaxation of the same muscles on the other side, accompanied by the contraction of the Ptergoide of the same, to draw it laterally in their contractions.

I must observe that in different individuals the maxillæ cross differently. In some the superior maxilla being on the right, in others on the left side. Yet in the same individual it always remains the same, just as in lobsters, in which sometimes the great claw, with its peculiar teeth, is on the right, sometimes on the left side.

Such is the structure, and such the uses of the bill of the Cross-beak ; yet the celebrated Buffon, without the smallest marks of diffidence, has given the following account, as void of sound philosophy as of the knowledge of facts.

L'espèce du Bec-croisé est très voisine de celle du gros-bec, ce sont des oiseaux de même grandeur, de même figure, ayant tous deux le même naturel, les mêmes appétits, et ne différenciant l'un de l'autre que par une espèce de difformité, qui se trouve dans le bec ; et cette difformité du bec-croisé qui seule distingue cet oiseau du gros-bec, le sépare aussi de tous les autres oiseaux ; car il est l'unique qui ait ce caractère ou plutôt ce défaut ; et la preuve que c'est plutôt un défaut : une erreur de nature, qu'un de ses traits constans, c'est que le type en est variable ; tandis qu'en tout il est fixe, et que toutes ses productions suivent une loi déterminée dans leur développement et une règle invariable dans leur position, au lieu que le bec de cet oiseau se trouve croisé tantôt à gauche et tantôt à droite dans différens individus. Et comme nous ne devons supposer à la nature que des vues fixes et des projets certains, invariables dans leur exécution, j'aime mieux attribuer cette différence de position, à l'usage que cet oiseau fait de son bec, qui serait toujours croisé du même côté si de certains individus ne se donnaient pas l'habitude de prendre leur nourriture à gauche au lieu de la prendre à droite ; comme dans l'espèce

humain on voit des personnes se servir de la main gauche de préférence à la droite. L'ambiguïté de position dans le bec de cet oiseau est encore accompagnée d'un autre défaut qui ne peut que lui être très incommode ; c'est un excès d'accroissement dans chaque mandibule du bec ; les deux pointes ne pouvant se rencontrer, l'oiseau ne peut ni becqueter, ni prendre de petits grains, ni saisir sa nourriture autrement que de côté ; et c'est par cette raison que s'il a commencé à la pendre à droite, le bec se trouve croisé à gauche, et vice versa.

I need make no comment on this description ; it is characterised by strong marks of error, carelessness, and presumption.

*On the final Cause of some Animals being White
in Winter and in Northern Climates.*

THOUGH the naturalist should be cautious not to be led from solid research and sound doctrine to vain and presumptuous speculation, yet, in many of his inquiries, he should keep final causes in view; they not only give a dignity to his study, but lead to discoveries; for the naturalist must sometimes inquire into the means by which nature accomplishes her plans, and sometimes, from a knowledge of the means, find out her designs.

So rare is the white colour amongst animals, that in general it is considered as the effects of domestication, or enfeebled constitution; yet it is well known that there are some animals in the high northern latitudes, and upon the snowy regions of mountains of milder climates, which are perennially white, and others that change their colour with the season, being white only during the winter.

The Polar Bear, which lives amidst ice and snow, and the Arctic Fox, an inhabitant of a similar climate, are perennially white;

whilst the Ermine, and the variety *Nivalis* of the common Weasel, with the variable Hare and the Ptarmigan, both inhabitants of the Scottish Alps, change their colour with the season.

What are all the advantages accruing from this colour I shall not attempt to assign. It appears probable to me that the principal use is, that, in this light coloured clothing, they may less attract the rays of the sun, which would thaw the ice or snow on which they repose, and the falling snow resting upon them, which, by wetting them, would chill them, and by freezing, upon the withdrawing of the sun, either load them with ice or freeze them to the ground.

It is a well known fact that dark coloured bodies become hotter than those in a similar situation of a lighter colour. This has been ascertained by accurate experiments with the thermometer; and it seems, from Mr. Saufsure's *Voyages dans les Alpes*, that the Swiss peasantry know how to apply this property of dark coloured bodies to practical use; for Mr. Saufsure, enquiring of some country people whom he observed scattering mould or soil upon their ground covered with snow,

was informed that they did it to hasten the melting of the snow.

If it be asked, why then is not the common Bear, which is found in very northern climates, and the Marmot, which lives amidst alpine snows, favoured with the same advantage; without pretending to assign the certain reason, it may be observed that these animals, during winter, rove not about for prey, but remain torpid in their holes and caverns, whilst the former, not having this torpid habit, are compelled by hunger to seek their food over the most bleak and stormy districts. And it by no means follows, that if this colour is a real advantage to them, that other animals of the same climate should likewise be favoured with it. This would probably rather destroy the equality than constitute it; for to different animals different means of offence, defence, and preservation are given. Horns to the Bull, hoofs to the Horse, tusks to the Boar, and teeth to the Lion; but fear and speed to the Hare; and, each being thus provided, the just economy of nature is kept up, but if cunning and skill, and speed and strength, and arms were to be centered in one, though some species might be favoured the police of nature would be destroyed.

On the Structure of the Husk of the OAT.

THE curious structure of seeds has often been noticed; and the various appendages of many of them, by which some are adapted, amongst other purposes, to be transported by winds, and others to be conveyed on the surface of streams and rivers, to distant parts: but I know not whether the contrivance of the husk of the animated Oat, (*avena gigantea*) by which it is adapted to sow itself, has been sufficiently observed; for, though the twisted structure of its awns, and their consequent fitness to serve as hygrometers, by their twisting and untwisting according to the dryness or humidity of the air, is well known, yet their principal use, together with the bristly beard which surrounds the base of the husk, has not, to my knowledge been attended to; and it is the conjunction of these two which gives it the power I just mentioned.

This intention of Nature is accomplished in the following manner. The awns, which are long and bent in the middle, untwist, as it is well known, by humidity, and twist again in siccity. With the changes therefore of the atmosphere (which are frequent, from the moisture of evening dews and nocturnal damps, succeeding to the dryness of the mid-day sun, which on its return again dispels these damps) the awns move, and as they are bent in the middle, whenever they twist or untwist, the upper part describes a circle, strikes against the neighbouring objects, and against the soil on which they rest, and move the whole seed and raise it from an horizontal to a more or less sloping direction. But the awns only move the seed; they do not give it progression. It is the beard that directs the motion, and renders it progressive, and this power is the consequence of the most simple contrivance; merely of the direction of the bristles of the beard, which are in an oblique direction from the base upwards. In consequence of this direction, whenever the oat is moved, if it lies upon a rough uneven surface as the soil or grass, the beard catches in the little inequalities, and at

every motion creeps a little forward, but never backwards, as the direction of the bristles prevent it. And whether the awns twist or untwist the motion is equally progressive, as it is the beard alone which gives progression to the motion.

Thus, by this simple structure, is this seed enabled to sow itself, and thereby to perpetuate its species. This power is not merely conjectural, and only supported by the appearance of the structure. I found it stand the test of experiment. I put one amongst the hair or bristles of a clothes brush, and another in a thick bunch of box, and, being exposed to alternate changes of dryness and humidity, they made their way through each.

*On the Cause of Objects appearing single,
though viewed with both Eyes.*

SEVERAL very celebrated philosophers have inquired into the reason why objects appear single when we view them with both eyes, but hitherto, I believe, not with the success to which their ingenuity had a claim. The inquiry, as well as the want of success in the elucidation of the subject, seems to me to have arisen from a misconception of the nature of our organs of sense. The following remarks, I think, will throw some light upon it, by shewing the analogies between the sense of sight, and our other senses, and further than to trace up this apparent anomaly to a general law of our economy, I do not presume.

If we attend to our organs of sense, we shall find that none of them lead us to think that the perceptions which we know to be created through their means, are felt in them, the sense of touch excepted. Except this

sense, they all, as simple organs of their respective senses, create in us their proper perceptions without producing any sensation in the organs themselves by whose means they are received ; just as the muscles of the body execute their several functions, without informing us of their useful ministry ; for we do not know, by sensation or instinct, the muscles we hourly employ, not even the voluntary muscles, and no more do we know the primary sources or organs of the sensations we feel. The perceptions are not felt in the organs, but only in the mind, which never refers us to the organs, but, as I said before, in the sense of touch. Hence it must follow, though none, who are capable of receiving knowledge by the tuition of experience, are ignorant that they see with their eyes and hear with their ears, that this is not from any sensation excited in them.

No sensation being then perceived in the primary sources of vision, any more than in our other organs, we in consequence know not with which eye we see any object, in so much that were one of them to be instantly affected by a gutta serena, unattended with pain, we should not be conscious of it. It

must be further observed, that, as each minute part of the surface of our body is a complete organ of the sense of touch, so is each part of all our other organs ; so that not only each retina, but each part of it, is a complete instrument of the sense of sight, and as such conveys to the mind not a mutilated but a perfect image ; perfect so far as its form and extent or *qualitas extensiva* ; each little part of the retina, on which the image of the objects of sight falls, producing all the effect of the entire retinae of the two eyes.

So far, therefore, as concerns one object, one part only of the retina, viz. that affected by the image, performs all the office of the whole retina, and the other parts are of no use, but to receive the impressions from other objects. And just as we can and do see, at the same time, with one eye, all the separate objects which come within the field of vision of that eye, each object (so far as the *qualitas extensiva*) in its integrity, without confusion ; so can we see, and do really see, at the same time, with each eye, some wholly separate and distinct objects, or even sets of objects, each eye for itself distinctly conveying its own proper images.

The greatest confusion would therefore be the consequence, if we really did receive double perceptions from single objects, when we viewed them with both our eyes, and then correct this error, as some have supposed, by a kind of habit. For as a single object seen with *one* eye ought, according to every opinion, to appear but as one object, and as each eye can and really does see some separate and distinct objects not seen by the other ; were single objects to appear double, when viewed with both eyes, we should never know whether objects were single or double ; that is whether we saw with each eye a separate similar body, that is two similar bodies, one with each eye, or one single object with both eyes. For all lateral objects are seen but with one eye ; and as we never know what we see with one eye and what we see with two, nor with which eye we see any object, nothing but the greatest confusion could be the consequence of the supposed original and natural method of seeing : this appears to me to be a strong objection to it.

But we shall find equally strong objections to this opinion, if we consider, that,

conformable to the other senses of our system, the *intensity* of our visual perceptions is increased when each eye receives a *similar* visual stimulus ; that is, that the *qualitas intensiva* is augmented by the increase of similar images, whenever their *qualitas extensiva*, or number is not increased. This requires no proof, as we all know, that, when we wish to view a very luminous body, as the sun, and the light is too strong for us, we, as it were by instinct, close one eye, and we are then able to look at it without inconvenience. That the intensity of sight is increased by our employing two eyes, is beyond dispute, and this increase is a strong argument with me in favour of the opinion that single objects do naturally appear to us as single objects and not as double ; for that which increases the number or *qualitas extensiva*, when corrected by habit or reasoning, should not increase the *qualitas intensiva*.

In this increase of intensity, through the duplicity of our organs, the sense of sight is not anomalous but analogous with our other senses. Though this sense, having, like the sense of touch, to take cognizance of the primary qualities of bodies, as their forms and numbers,

it is a natural consequence of its ability to execute this office, that it should keep distinct the similar forms, and to this end that the separate similar impressions of one eye should not coalesce or unite into one great one, as in our other senses ; for every object is composed of parts, some of which are similar and some dissimilar ; if then the similar impressions of one eye should coalesce into one, we should not see objects as they are, but mutilated and monstrous. But in other respects the sense of sight is like the other senses ; for as this keeps the similar impressions of the objects of sight of one eye distinct, yet unites the similar of the two ; so the sense of hearing, where each ear is a perfect organ, keeps separate, that is, distinguishes the different sounds heard at one time by one ear, yet unites into one the similar heard by the two ; for a sound is but one, though heard with both ears ; but it is more intense, that is louder when heard with both than with only one. The sense of taste keeps separate the different perceptions, that is, distinguishes the different tastes perceived at one time ; yet if a small part of the tongue is affected by the sweetness or saltiness of a body, or both, though we

feel these perceptions, yet they are not so intense as if a greater part of the tongue was affected. In the sense of smell it is the same : and it is the same in the sense of touch, when the primary qualities of bodies are not its objects ; for pain and pleasure, and heat and cold, are greater by their causes acting upon a greater part of the sense of touch ; though this sense, like the sense of sight, having to ascertain the situation of bodies by referring each to its real situation, must necessarily keep separate the similar perceptions of their mere presence.

I therefore repeat, that, according to the economy of our system, each part of an organ of sense is a perfect organ, and its extent or number only adapts it to receive several dissimilar impressions, or to encrease the intensity of the similar. And as each specific stimulus, however faint, is as complete an impression upon its own proper organ, so far as the *qualitas extensiva*, as the images on the retina, and as all similar stimuli, from the secondary qualities of bodies, only encrease the intensity, and not the number of our sensations, I can see no reason why we should consider the unity of visual perceptions arising

from single objects seen with two eyes as anomalous in our system, and then invent ingenious hypotheses to explain it. To me the sense of sight appears analogous to our other senses, in which we well know, that neither the extent or number of the organs ever multiply our perceptions, so that had we an hundred organs of each sense, objects of sight, and sounds, tastes and smells, would remain in their unity.

Objections against the Perceptivity of Plants, so far as is evinced by their external motions.

HOWEVER sanguine we may be in our expectations of extending the limits of human knowledge, we cannot avoid perceiving that there are boundaries which it never can exceed. These boundaries are formed by the limited faculties of the human mind, which, though fully sufficient to answer all the purposes of common life, are often inadequate to

the task in which speculation excites them to engage. None ought to feel more the truth of this observation than those engaged in physiological enquiries, where the operations of nature are so complicated, and at the same time carried on in so secret a manner, as to keep us ignorant of the causes of the most common phenomena.

If physiologists have been unsuccessful in many of their inquiries into the animal economy, they have been still more so with respect to the vegetable: for how little do we know at this day of the course of the fluids of plants, and of the power by which they are moved! Are we not in our knowledge of the vegetable kingdom, where we were near two centuries ago in the animal, when the great *Harvey* withdrew the veil?

The many beautiful analogies existing between the two organized kingdoms of nature, as, their similar origin from egg or seed, their subsequent developement, and nourishment by intus-susception; the power of continuing their species, the limited time of their existence, and, when not carried off by disease and premature death, possessing in themselves the cause of their own destruction, have been so favour-

able to the supposition of the existence of a complete chain of beings, that there appeared to the favourers of this opinion nothing to be wanting to connect them, but the loco-motive faculty; for irritability, from some appearances in a few vegetables, had by some been granted them. This loco-motive faculty, which is considered as the consequence of volition, which is an attribute of mind, it is said* is manifested in the direction of the roots towards the soil which affords them their most proper nourishment, and in the direction of their tender shoots and leaves towards the light, which is likewise necessary to their well being.— These facts are admitted, but not the consequences drawn from them.

It must indeed be allowed, that vegetables do on some occasions act as though possessed of volition, avoiding those things that are injurious to them, and turning towards those that are beneficial; thus appearing to act by choice, which must be preceded by perceptivity, a favor that nature has granted, I think, to the animal world alone. The following facts are brought as examples.†

* In the Manchester Transactions.

† Idem.

A Plane-tree, twenty feet high, growing upon the top of a wall, straitened for nourishment in that barren situation, directed its roots down the side of the wall till they reached the ground ten feet below. It has been amply repaid, it is said, for its trouble ever since by plenty of nourishment, and a more vigorous vegetation has been the consequence. On another occasion, a plant being placed in a dark room, where light was admitted only through an aperture, put forth its shoots towards the aperture, which elongating passed through it; and this likewise was rewarded for its trouble by plenty of light and free air.

That appearances so similar to those that are observed in animals should be considered as proceeding from the same cause, viz. volition, is not to be wondered at, when so many of the inferior orders of animals hardly possess so much of the loco-motive faculty; particularly by men of warm imaginations, who, prepossessed in favour of an opinion, were grasping at every distant analogy to support it. Though, as I have said, we are by no means acquainted with the course of their proper fluids (*succi proprii*) or with the power by which they are moved, nor even can say

by what power it is the fluids, which are its food, are taken in; yet so far we know, that here, as in the animal economy, there is a constant change and evolution of their fluids, and that a constant supply is necessary, without which they soon perish.

This supply, so necessary, must be taken in by absorption; and it is this act of absorption that I shall endeavour to prove to be the efficient cause of these motions in vegetables, and thus exclude volition from being the cause of these phænomena; for it is from their not having been explained upon mechanical principles that mind has been resorted to; mind is in general our last resource when we fail in explaining natural phænomena. I could wish that physiologists were agreed upon the kind of absorption that takes place here, whether it is by active open mouthed vessels, which, according to the common opinion, takes place in the animal economy, or by capillary attraction, which is the most general opinion in the vegetable; but the theory I propose will accord with either.

The first consideration is, that an inert fluid is in motion. Secondly, That, posses-

ing no motion in itself, it owes this motion to the plant. Thirdly, That as action and reaction are equal, whilst the plant draws the fluid towards itself, it must be drawn towards the fluid, and that in the reverse ratios of their respective resistances.

Now whether this absorption be performed by vessels acting as in the animal economy, or by vessels of the nature of capillary tubes, is of little moment, it is only requisite that an absorption be admitted; for it is evident, that if action and reaction be the same, the absorbed fluids, which possess no motion in themselves, cannot be put in motion by the open-mouthed active vessels, without being drawn in the direction of the fluids absorbed. But should we prefer the theory which explains this absorption by capillary attraction, which theory I think is the most prevalent, we shall still find that the absorbing vessels are drawn towards the fluid. This is equally as true as evident, whether applied to that simple hydraulic instrument, the straw, through which the school-boy sucks, or to the most complicated machine of the natural philosopher.

These principles will, I think, be sufficient to explain those appearances in vegetables which have served as a foundation, or have been considered as signs of their perceptivity and volition, and which, as far as I am informed, have never been attempted to be explained, viz. the direction of their roots towards the soil which affords them the best nourishment, and of the young and tender shoots towards the light: for here is an absorption of water and light. The absorption of water is easily ascertained; but that of light, by its subtleness, eludes our experiments, with probably many other fluids of great importance to the healthy state of the vegetable world.

To make the connection more complete between the two organic kingdoms, it has not only been said that plants move towards their food, like wise and intelligent beings, but that they likewise turn aside from those soils, &c. which are injurious to them, or at least afford them but a scanty nourishment. This is a deception: they do not turn aside; this apparent dereliction is only the direction and immediate consequence of their motion towards their nourishment, for when the root of a tree

or plant changes its course, on account of meeting with a rock, or with a hard, stiff and barren clay, or other object that does not afford it proper nourishment, it arises not from any aversion to these objects, but to there being no attraction from absorption acting in that direction, but one from a more favourable soil. The feebleness of the resistance, and the consequent feebleness of the attraction of these fluids, cannot be urged against this theory: the motion to be explained is only the tendency of the nascent shoots; no one having pretended that the solid wood could turn aside or alter its direction; and this power, however feeble, is always acting.

I am not ignorant that these are not the only motions which are thought to announce the perceptivity of plants. The motions observed in the stamina and other parts, at the time of fecundation, the spiral direction of the stems of some,* the use of the cirrhi of

* I have read and heard it more than once asserted, that the *Lonicera* and other plants with the *caulis volubilis*, which twine either *dextrorsum* or *sinistrorsum*, can change this natural direction; so that when two *Loniceræ*, or two branches of the same *Lonicera*, meet, the

others, and the bursting of the capsules, have all, with many other powers, been thought to favour this opinion. These are powers naturally arising from their respective organizations, that nature has bestowed upon them for their preservation and re-production, and which can no more be considered as the consequence of volition, than the fall of their leaves at stated periods, their growth and decay; which have never been considered as the consequence of mind, any more than the increase, changes, and destruction of animal bodies, the efficient cause of which exists in their peculiar organization, but which may for ever elude our researches.

When all is considered, I think we shall place this opinion amongst the many pleasing effusions of the imagination, rather than view it as a profound speculation of well directed genius and philosophical research; and so-

one turns to the right, the other to the left, that they may afford to each other a better support. This is a mistake, and, if true, would only counteract the intention of nature, which is that, thus entwined, each may obtain support. All twisted bodies, to unite, must twist in the same direction.

berly follow that blind impulse which leads us naturally to give sensation and perceptivity to animal life, and to deny it to vegetables; and so still say, with Aristotle, *vegetabilia crescunt & vivunt, animalia crescunt, vivunt, & sentiunt*.

On a kind of Plica in a Hare.

WHILST I was at Göttingen, amongst other objects of natural history, a young Hare was brought me, so young that I at first kept it in a bird cage. It soon became a favourite pet, and would sit or sleep on my sopha and bed. In the evening it was very frolicksome and gay, and was used to leap upon my bed, and, in playfulness, beat me with its fore feet, and knock my book out of my hand if reading. Notwithstanding this familiarity it was extremely timid, and did me much mischief more than once upon the entrance of a stranger. I kept it about a twelvemonth, till I left this university. I then took it in a bag into an ex-

tensive wood a few miles off, and sitting down let it out. It did not run away, but began to brouse, yet by degrees went farther off. When it was at some distance I went towards it and it sat down, but when I got within about a dozen or twenty yards it was seized with fear, sat off at full speed, and I saw it no more. I intrude these trifling remarks of my little favourite only that I may mention a very singular disease to which it was subject. It was something of the nature of a *plica*, but differed in this material circumstance, that the extravasation was not serum but blood. In degree the disease was very trifling, and I should not have noticed it had I not frequently observed little red streaks on my hands after playing with it; and then I could but guess their cause. My conjecture I confirmed by passing a piece of white paper over it, which became marked with little red streaks. On a close examination, I could perceive a great many very minute grains adhering to its hair. I brushed some off, and dissolved them in water, and they seemed to differ in nothing from clotted blood. The disease, if it can be called so, was so mild, that I never found above five or six hairs clotted together, and

the grains were as small as fine grained gun powder. This exudation did not come out from the base or bottom of the hairs, but from the middle, and towards the points. It continued, I believe, for some months, and till I gave my little friend his liberty, who in other respects was always in perfect health.

On the Common Rabbit producing Angora Rabbits.

LATELY, at a house in Liverpool where I lodged, the children showed me their Rabbits, when I was surprized to see several young ones, with the hair just like the Angora breed. All of the same litter were not the same in this respect; some differing in nothing from the common breed to which their parents belonged. I asked if any of the Angora breed had access to theirs, they said no, but informed me it was not the first time they had had this variety from the same parents.

On Clearing Corn from Weevels.

A few years ago, whilst I was passing some days at a nobleman's seat in Vivarais, in France, I was taken into a granary to see the dreadful havock the little *Curculio granarius* had made, and was still making, in a considerable quantity of wheat that had been kept rather long, on account of the low price at which it then sold. The grain looked black through their numbers, and the walls just above the corn were covered with them. We agreed to try the influence of the sun, and accordingly the wheat was brought down and exposed on sheets to the sun's meridian heat. This scheme succeeded; they immediately crawled away as fast as they could, and, by stirring the corn, we completely got rid of them.

On the Measurement of Fishes.

WHEN I had a prospect a few years since of going out to India, to make discoveries in mineralogy and geology, I did not intend wholly to neglect the other branches of natural history. Amongst some contrivances for facilitating the drawing and the describing of natural objects, I planned the following easy method of measuring the proportions of the different parts of fishes, and other animals which might admit of it.—A hundred rays, or eccentric equi-distant lines, diverging from a common centre like the sticks of a fan, are to be drawn on a sheet of paper, or, for the convenience of the travelling naturalist, upon his pocket handkerchief. The fish is then applied to this measure, and is thus divided into an hundred equal parts; and thus the proportions of all the parts, with their distances from each other, are ascertained, and then noted down. By this means, of whatever sizes fishes of the same species and relative propor-

tions may be, the numbers in the descriptions will be the same. The only difference on account of size is, that the small ones must of course be brought near the centre, as in every case the extremities of the fishes must be brought to touch the first and last rays. Mr. Broussonet, I know, in his much esteemed *Ichthyologia*, &c. has given another method of measuring fishes, which I do not recollect, but so far I recollect, that when two fishes of the same species and proportions, but of different sizes, are described, an arithmetical process is requisite to know whether the figures correspond; that is whether the proportions are the same: this is certainly a great inconvenience.



Of the Julus oniscoides.

ABOUT eight or nine years ago I found, under some loose stones at the foot of Salisbury Craggs, near Edinburgh, a new, and very singular species of *Julus*, having the true characters of a *Julus*, with the form and size of the *Oniscus Armadillo*. I took a few live

specimens with me to Copenhagen, and Upsala, where they were unknown. I found them afterwards pretty common in the decayed stumps of trees in the woods about Göttingen, where I shewed them to several friends, and, amongst others, to the indefatigable naturalist, Mr. P. as a new species of *Julus* which I called, from its great similarity to the *Oniscus Armadillo*, *Julus oniscoides*. Mr. P. forgetting soon after that I had first shewn it him, and pointed it out as a new species of *Julus*, sent it to Nuremberg, where it was figured and described as a new species of *Oniscus*.

This species so much resembles the *Oniscus Armadillo* that it is no uncommon thing to find it in the apothecary's shops amongst the millipedes. At Edinburgh I found them in Coitu. They unite in the manner of the *Libellulæ*, the end of the abdomen of one meeting the thorax of the other. They form themselves into balls like the *Oniscus Armadillo*. But it should by no means be thought that this form is characteristic and exclusively so, of the genus *Oniscus*. All the species of *Julus* I am acquainted with assume a spiral form, which, in a long animal, corresponds to the ball of the short; each form being that in

which the animal is most compact and least exposed. As I am at a great distance from my collection of insects, I cannot give a figure of this curious species: but I find amongst my papers the following description, written at the time.

JULUS ONISCOIDES. Latitudo tertia longitudinis, pedibus utrinque circiter 18.

Ater oblongus longitudine unguis. Segmenta corporum 12 preter caput, primum aut cervicale minimum semicirculare, secundum & ultimum latiora, marginibus albidis.

HABITAT in locis humidis Scotiæ sub lapidibus, & in Sylvis Germaniæ sat frequens in stipitibus putridis.

OB. Mihi videtur non rarus esse at pro Onisco Armadillo habetur.

On the final Cause of our Aversion to tread on soft Bodies, &c.

THOSE who consider man, with regard to his moral powers, as the mere creature of tuition, example, and habit, are excused by their principles from attending to his instincts; but they who consider these as the primary sources of action of all animated be-

ings, and as specific in their kinds, though requiring, like the faculties of the body, time and circumstances to their developement, should find a peculiar pleasure in the contemplation of the least of them.

It may be thought fanciful, yet I think I discern a kind provision of nature in favour of the smaller tribes of creeping things manifest in the dislike, and even disgust, we feel on treading upon them, or any thing that is either soft or that scrunches under our feet. I have seen people much displeased upon treading on a pin-cushion that had accidentally fallen on the floor, and the scrunching of ashes under our feet I have often observed to be disagreeable to many. Few, I think, but in their thoughtless hours, can crush under their feet, without disgust, a poor beetle, or harmless frog or toad. In this I do not rely on my own feelings, which, from my affection for the whole brute creation, have acquired a painful sensibility.

But this attention of nature towards these smaller animals is not anomalous; has she not made a similar provision for the larger kinds in the pain and even horror we feel at their cries and contortions, when in distress and

agony? but, in such small animals, these expressions of misery are too minute and feeble to call forth pity and commiseration; nature therefore has provided for them in another way.

If there are some who, without concern, can crush these helpless creatures under their feet, this is no objection to my opinion, for it must be remembered that they live under a general anathema, and they who destroy them are taught, from their early years, to consider their destruction as requisite. Though no one will say that cries and dying agonies do not naturally excite to pity, and are therefore a benevolent provision against hardheartedness and cruelty, yet we know that, urged by a brutal custom, a gentle female heart has often suffered its trembling hand to plunge the knife into the throat or heart of the fainting deer. Customs and habits may obliterate our natural sympathies, and prejudices may support us in cruelty, yet still, it is true, that nature has made a provision for the cultivation of the former, and for the suppression of the latter.

On the Instinct of a Mouse.

WHEN I was at Vienna, a few years ago, I had an opportunity of observing a singular instance of persevering industry and blind instinct in a Mouse which I had caught in my room, and kept for some time between the double sashes of my window.* One of the panes of glass was cracked, here he worked with unremitting diligence to gnaw his way through. Though, as it may be supposed, he could make no impression, or scarce any on the glass, and in the evening his work seemed no further advanced than when he began in the morning, yet was he not disheartened, but day after day renewed his efforts to gnaw his way out at the crack: the frame, though of wood, he never attempted. After I had kept him a fortnight or three weeks, and he was apparently in good health, he was seized with a fit and instantly expired. On examining the glass, I found he had just chipped off the edges at the crack.

* At Vienna, and some other cities on the Continent, many of the houses have, during the winter, double sashes to the windows.*

On the Bull-Finch.

IT has been long not only a popular opinion, but likewise the opinion of naturalists, that Bull-finches eat the fruit-buds of several kinds of fruit trees, and consequently do a great deal of mischief in gardens. In a late publication on birds, which has been well received by the public, the author kindly endeavours to exculpate them, by saying that they only eat the insects that lye concealed in the buds, and are therefore the friends, not the rivals, of the lovers of fruit.

I am sorry I must contradict this favourable opinion, and accuse them of the most extravagant luxury. In February of this year, I opened the stomachs of two that were shot in a cherry tree, and, exclusive of a few grains of sand and some small pebbles, I found nothing but the embrio flowers. I could discover, by the assistance of my lens, all the parts of the flowers. The mischief these two little epicures had done, and probably at one breakfast, is incredible. From the quantity

of buds I found in their stomachs, each of which was composed of four or five flowers, I think they had not eaten less than a thousand a piece. This certainly is as culpable a gluttony as feeding upon the spawn of mullets, or the eggs of ortolans.

A Sketch of the Mineralogy of Shropshire.

NOTWITHSTANDING the advantage to science, public economy, and private interest, which would result from such an undertaking, I am afraid there is but little probability of a mineralogical survey of this kingdom being made for many years: till then we must be thankful for partial accounts and sketches of districts.

The following sketch of the mineralogy of Shropshire is the result of several little excursions made at very different times; sometimes, in true style, on foot, with hammer in hand, other times on horseback. This will explain why sometimes I am minute and enter

into detail, and why I sometimes merely sketch. It is by no means given to the public as a mineralogical survey.

The county of Shropshire admits of a natural division into two parts; the flat and the hilly; and these are pretty accurately marked by the course of the Severn. Through all the northern part of the county, from the Severn at Shrewsbury to the confines of Cheshire in the north; and from Drayton on the borders of Staffordshire on the east, to Oswestry on the borders of Wales in the west, it is flat; varied only by gentle swells, and here and there some naked rocks. But on the southern side of the Severn, from near Shrewsbury to Ludlow on the borders of Hereford on the south, and from Bridgnorth on the borders of Staffordshire on the east, to Bishop's Castle on the borders of Montgomery on the west; the country is very hilly. Yet, to be more accurate, it must be observed that the hilly district, on the eastern side of the county, begins just on the north side of the Severn where the Wrekin rises from the plain.

Throughout the flat district, common sandstone prevails, and forms in some places considerable rocks, as at Grinsell, Nefsclyff and

Hawkeston. Both red and white are common, and both are used in building; neither has a calcareous cement. The gentle swells that prevail in this district consist chiefly of gravel, composed of different kinds of hard siliceous sandstones, compound sandstone, and quartz. The nature of the gravel varies, I suppose, according to the proximity of different rocks.

At Llanymynych, near the confines of Montgomeryshire, a range of limestone rocks begins, which is in some parts of considerable height. The strata rise towards the Welch mountains, and vary a little in texture and colour. Many deep excavations on the top of the highest hill indicate that mines have been worked here in some, probably, very remote period. Calamine, lead, and copper, are still got, but in small quantities. Here I found amongst the rubbish from the mines a piece of madrepor in the state of limestone; on breaking it I found the sides covered with a thin coating of galena lead ore.

At Oswestry the country rises towards the north west, and the hill called the Cerny-Buch is a coarse grained sandstone, very different from that found in the flat country.

This leans upon limestone, which, at a quarry belonging to Mr. Lloyd of Aston, forms a bold precipitous range of rocks that face the Welch hills in the N.W. and seem to extend to a considerable distance. This limestone contains many petrifications and a great quantity of black flint approaching to chert; it is not like the flint distinct from the rock and in polymorphous nodules, but in small irregular masses, insensibly uniting with the limestone.

Two or three miles S. W. of Oswestry are the collieries of Llwynymain and some others; they seem to rest upon the lately mentioned coarse sandstone strata. The argillaceous and sandstone strata which accompany the coal are very rich in vegetable impressions. In the colliery of Llwynymain I found a very curious, and I may, I believe, say, a new species of ironstone. It has the brown colour and the weight of the common argillaceous ironstone, but has a very rough uneven fracture, a coarse granular texture, and glitters with innumerable specks, as though it contained minute spangles of mica. After a close investigation with a lens and nitrous acid, I ascertained it to be a mixture of spatous

iron ore and the common argillaceous ironstone. The spatous ore, which is in small grains not bigger than a pin's head, and apparently spherical, with excentric or divergent rays, seems to be nearly equal in quantity to the common ironstone, which may be considered as the ground or cementing matter. I knew not when I was on the spot what it was, otherwise I should have examined into its situation and circumstances more particularly. It seems to exist in great masses, and likewise in nodules, like the common ironstone. As the best iron and steel, those of Styria, are made of spatous iron ore, this may, I think, be found a valuable ore.

Near the Severn, and two or three miles N. E. of Shrewsbury, is Haughman-Hill. This is of compound sandstone, * and the strata where I observed them were vertical. About ten miles east of Shrewsbury, the Wrekin, the most celebrated hill in the county, rises from the plain near the banks of the Severn; it is a ridge hill, about two miles long, running nearly north east and south west. The land is considerably higher

* This will be explained under the article Longmont.

on its eastern side, as the country here begins to rise into hills. About three years ago I ascended this hill. It is chiefly composed of a reddish coloured chert, which in some parts has the spotted and variegated appearance of Breccia. I recollect to have seen in one part a bed or an immense mass of hard close grained siliceous sandstone. In another part wacké or basalt is found, and in another a granitoid rock, composed almost wholly of small grained red feldspar, with a little quartz and some minute specks of a greenish matter, probably of the nature of hornblende. This hill, or mountain, as it may be called, belongs to the primitive. It has no regular stratification, is without any mineral veins, and produces nothing valuable. To the N. E. of the Wrekin lie the Arcall Hills. That nearest the Wrekin is chiefly composed of the hard close grained siliceous sandstone, with some wacké or basalt. The other appears, from a quarry that is opened, to be chiefly of chert, yet the siliceous sandstone is found likewise here, and some of it has been used in a pottery at Coalport, in this district. Wacké or basalt is again seen here. The quarry of chert is covered by a bed of a very singular kind of red gravel

about four or five feet thick, composed of small fragments and the small debris or sand of the granitoid rock. To the east of these hills lies the Steeraway Hill. This is formed of limestone strata, sandstone strata, and clay strata; they dip to the east, and near these hills with an angle of about 45 degrees, but fall flatter more to the east. Though the Wrekin is very unproductive, it is at the foot of this hill that the greatest mineral wealth of the county is deposited.

The Coal district of Coalbrook Dale, lies on the east side of the Wrekin, runs parallel with it from from the N.E. to the S. W.* and is about eight miles long and two broad. It is first observed on the other side of the Severn, in the parishes of Barrow and Much Wenlock, and runs through those of Brosely, Madely, Little Wenlock, Wellington, Dawley, Malins Lea, Shifnall and Lilleshall. The whole, but especially the southern part of this coal district, is considerably above the level of the plain of Shropshire, so

* This account of the coal district was communicated by Mr. William Reynolds of Ketley.

that near Horsehay it is 500 feet above the river Severn which flows in its neighbourhood. The dip of the strata varies; in the parish of Madeley it is towards the east, and near Wellington and Linsell it is from north to north east, about one yard in ten.

The support or foundation of the coal, and its accompanying strata, is dye-earth and basalt. The former lies on the east side, and the latter on the west. The dye-earth is a grey dry clay, which effervesces with acids,* and contains petrifications chiefly of the Dudley-fossil kind, and some small bivalves. It is a stratified mass, and at Tickwood, in the neighbourhood of Coalbrook Dale, may be seen to be at least an hundred yards thick. The basalt varies from the softer and lighter kind, called wacké, to true basalt. In some places in the parishes of Brosely, Madeley, Little Wenlock, Wellington, and Lilleshall, limestone is found as the support of the coal strata.

* From a rough analysis made by a friend it appears to consist of about 58 of argil. 26 of cal. E. and 16 of silex.

At Wombridge, in the northern part of the coal district, the following strata are found. I must observe that this is in the western swamp or depression of the strata, for, on the elevated part, the first twenty strata are generally wanting.

- | | | | |
|---|---------------|----------|--|
| 1 | Top Rock * | 27 feet. | It is an argillaceous yellowish sandstone. |
| 2 | White Clay | 18 |a blackish grey plastic clay. |
| 3 | Chance Coal | 9 inch. | |
| 4 | White Tough | 2 feet. |a blackish grey plastic clay. |
| 5 | Ash Ball Rock | 18 |a heterogenous mixture of small fragments of greenish grey clay, of reddish chert and white quartz. |
| 6 | Rocky Marl | 18 |a reddish brown dry * shivery clay. |

* These are the Colliers names.

† I have divided the clay strata into three kinds; the *plastic*, which are soft ductile clays. The *dry*, which may easily be scratched with the nail, and are not ductile till after long exposure; and the *basies*, which cannot well be scratched with the nail, are shistose, black, and generally gives a black scratch.

- 7 Gritty Rock 6 feet. It is a white sandtone, but of so extremely fine a grain that it appears as a compact ungranulated mass.
- 8 Rocky Marl 13the same as N. 5, but of much minuter parts, and mixed with some of the red clay of No. 6.
- 9 Gritty Rock 5a fine grained grey sandstone, containing mica.
- 10 Rocky Marl 9a reddish brown clay and whitish clay mixt, nearly the same as No. 6.
- 11 Gritty Rock 4a whitish sandstone.
- 12 Ash Ball Measure 84the same as No. 8. but without the red clay.
- 13 White Rock 3a very fine grained white sandstone.
- 14 Rocky Marl 11the same as No. 8.
- 15 Rock 2a very fine sandstone like No. 7.
- 16 Tough soft Clay 18 incha blackish grey plastic clay.
- 17 Hard Rock 4 feeta grey sandstone of so fine a grain as to appear compact to the naked eye, and containing very minute particles of mica.
- 18 Top Pinny Measure } 8beds and nodules of ironstone, in a blackish grey dry clay.
- 19 Black Slums 18 incha greyish black slippery dry clay.

20	Fungous Coal } Rock }	36 feet	It is a coarse grained whitish sandstone.
21	Fungous Coal	3	an excellent coal.
22	Fungous Coal } Poundstone }	4	a greyish black dry clay.
23	Foot Coal	1	not got.
24	Black Stone	4	a black grey ironstone in nodules, in a greyish black dry clay.
25	Stone Coal	4	a good coal.
26	Tough Pound- } stone }	3	a black slippery dry clay.
27	Gur Coal	2	not got.
28	White Clunch	4	blackish grey dry clay.
29	Gray Rock	4	a light grey fine grained sandstone.
30	Brick Measure	16	alternating strata of grey coloured ironstone and dry clay.
31	Bind Bafs	6	a black dry clay.
32	Bind	7	a brownish grey very fine grained argillaceous sandstone.
33	Ball Stone	9	grey coloured ironstone in nodules, in dry clay. These nodules contain fern leaves and other vegetable impressions.
34	Dun Earth	6	Ironstone nodules in a grey dry clay.
35	Top Coal Bafs	4 inch.	a black bafs or indurated shistose clay (schiefer Thon.)
36	Top Coal	5 ft.	This is one of the best coals in Shropshire.

- | | | | | |
|----|---------------------------|---|---------|---|
| 37 | Top Coal
poundstone | } | 1 feet | It is a greyish black dry slip-
pery clay. |
| 38 | Slums | | 4 |a black slippery dry clay. |
| 39 | Three-quar-
ter Coal | } | 2 |never got. |
| 40 | Double Coal
Rock | } | 6 |a very fine grained whit-
ish sandstone. |
| 41 | Double Coal | | 6 |a good coal much used. |
| 42 | Double Coal
Poundstone | } | 18 inch |a greyish black dry clay. |
| 43 | Yellow-stone
Earth | } | 6 feet |iron stone in short thick
masses in a shivery
blackish grey dry clay.
This ironstone contains
in its cavities blende and
terra-ponderosa vitriol. |
| 44 | Yard Coal | | 3 |sometimes got. |
| 45 | Yard Coal
poundstone | } | 9 inch |a black dry clay ap-
proaching the nature of
a basf. |
| 46 | Quoice Neck | | 9 |greyish black dry clay,
with very shining sur-
faces. |
| 47 | Blue Flat | | 6 feet |alternating strata of
brownish grey ironstone
in dry clay; the iron-
stone in the upper part
is in nodules. |
| 48 | Pitcher Basfs | | 5 |a black basf or indurated
shistose clay (schiefer
Thon.) like No. 36 |
| 49 | White Flat | | 4 |alternating beds of iron-
stone in a black grey
shivery dry clay. |

- 50 Flint Coal Rock 10 feet. It is a fine grained whitish sandstone, with some mica.
- 51 Flint Coal Roof 13a blackish grey dry clay.
- 52 Flint Coal 5a good burning coal ; at Madeley-wood it is impregnated with falt-water.
- 53 Flint 21a fine grained whitish sandstone, used for building.
- 54 Pinny Measure 24a blackish grey dry clay, containing iron nodules. It is in the upper part of this stratum, close under the flint, that the Curl is found.
- 55 Stinking Coal 5a coal containing a great quantity of pyrites which are used for vitriol : this coal being cheap it is chiefly consumed in burning brick, lime, &c.
- 56 Stinking Coal } 18 incha greyish black dry clay.
Bafs }
- 57 Upper Clunch } 10a good coal, but being so
Coal } thin it is not got, except where the coal above is worked open.
- 58 Upper Clunch 3 feet.a light grey shivery dry clay, much used for fire-bricks.
- 59 Clunch Coal 2never got.

- 60 Lower Clunch 6 feet. It is a grey dry clay used for fire-bricks.
- 61 Two foot Coal 2sometimes got.
- 62 Linsed Earth 12a dark black-gray dry clay, used for fire-bricks.
- 63 Best Coal 9 inch. In the northern part, but 2 feet in the southern; this is the best coal.
- 64 Randle Coal 3 feet. It is the best smith's coal.
- 65 Bannack 2a brownish grey very slippery dry clay, good for fire-bricks.
- 66 Clod Coal 4 This is the coal used for smelting all the Shropshire iron.
- 67 Pale Blue Clod $4\frac{1}{2}$ a blueish grey clay, with vegetable impressions.
- 68 Sandstone 9a fine grained argillaceous sandstone, containing vegetable impressions.
- 69 Little Flint Coal 2a good burning coal.
- 70 Little Flint from 10 to 45a very fine grained white sandstone.

Thus we have a mass of strata about 550 feet thick.

The Little-flint is the lowest coal-stratum, and then either the dye-earth, basalt, or limestone is found. But this order of strata which is found at Wombridge in the north, does

not continue through the whole coal district. At Broseley and Madeley, in the south, the following order of strata is found. Unfortunately, from the pits not having been lately sunk through the upper strata, but from a level or adit in the side of the hill, the upper strata here are not accurately known. So far however is known, that there is first an immense bed of red sandstone, then, for about a hundred yards, alternating strata of sandstone, argillaceous sandstone, strata of clay, and thin strata of coal from one to four inches thick, then

a whitish Rock. An argillaceous Sandstone	21 feet
a small surphurous Coal	8 inches
a blueish Clod. A dry Clay	14 feet
a small Coal	2 inches
a whitish Clay, containing Nodules of Ironstone	2 feet
a brownish Sandstone coloured by Petroleum	13
a blueish Clay, with vegetable impressions	5
a plastic Clay, with small Strata of Coal, one and two Inches thick	6
a Coal, called the Upper Stinking Coal	8 inches
a whitish dry Clay	1 foot
a blueish grey argillaceous Sandstone	13 feet
a brown ditto ditto	9
a reddish dry Clay, with a little Hæmatites	2½
a grey argillaceous Sandstone	7
a brown plastic Clay	2
a whitish dry Clay	5
a reddish dry Clay, with a little Hæmatites	6
a brown Sandstone	18

a fine reddish dry Clay	....	....	....	11 feet
a greyish fine grained argil. Sandstone	....	....	....	11
a dry Clay, including two small Strata of Coal,				
one fix, the other seven Inches	....	....	....	6
a Stinking Coal. Got	....	....	....	$1\frac{1}{2}$
a grey argillaceous Sandstone	....	....	....	11
a reddish argillaceous Sandstone	....	....	....	15
the upper Part of the rough Rock, which is a				
very coarse Sandstone without Bitumen				15
a grey dry Clay	....	....	....	3
the lower Part of the rough Rock which is a				
kind of very coarse sandstone contain-				
ing Bitumen	....	....	....	27
a brownish dry Clay	....	....	....	20
Top Coal, which is the fame that in the				
former list is called the Yard Coal	....	....	....	$2\frac{1}{4}$
The Blacks. A blackish dry Clay	....	....	....	7
The Silk Coal	....	....	....	8 inches
a Bafs, a black indurated shistose Clay	....	....	....	$1\frac{1}{2}$ foot
a dry Clay, containing very good Ironstone				2
Bottom Coal, called in the other list Flint Coal				3

After this stratum, the strata, in part, correspond with those of the preceding lists in respect to the order, but not to their thickness, as the following list shews.

The Flint	....	....	....	....	15 feet
The Pinny Measure, (no Curl is found in					
this Stratum here, though it is at the					
Mine where the other list was taken,					
and scarcely ever any shells, though					
often found in this Stratum in the ele-					
vated part of the district in the parish					
of Little Wenlock)	....	....	....	....	9

The Stinking Coal, containing but a small quantity of Pyrites, and this much more earthy than that of the other Mine, so that this is not used for

Copperas	....	....	....	....	18 inches
The Upper Clunch	....	....	....	....	12 feet
An Argillaceous Sandstone	....	....	....	....	21
The Two-foot Coal	....	....	....	....	2
A Dry Clay	....	....	....	....	12
The Vigo Coal, sometimes got, when near the					
Surface, for burning Bricks	....	....	....	....	1 foot
An Argillaceous Sandstone	....	....	....	....	1
The Ganey Coal, sometimes got	....	....	....	....	2 $\frac{1}{4}$ feet
A dry Clay, this is the Linseed Earth of the					
first List	....	....	....	....	7 $\frac{1}{2}$
The best Coal, this is got in the Parish of					
Madeley	....	....	....	....	2
A Bafs	....	....	....	....	9 inches
The Middle Coal, the Randle Coal of the first					
List	....	....	....	....	2 $\frac{1}{2}$ feet
A dry Coal, the Bannack of the first List	....	....	....	....	6 inches
The Clod Coal	....	....	....	....	2 feet
Clod Coal Poundstone, the pale blue Clod					
of ditto	....	....	....	....	7
Hard Sandstone, sometimes containing No-					
dules of Ironstone	....	....	....	....	3
Little Flint Coal, got in the Parish of Made-					
ley, and esteemed a very good Coal	....	....	....	....	3
Little Flint Rock, the little Flint of the other					
List : here it contains a good deal of	....	....	....	....	
Ironstone called Crawstone, from 20 to 80 feet.					

Then the dye earth is found. Thus we have a mass of strata about 400 feet thick.

The coal district of Coalbrookdale, like other extended coal fields, is troubled with faults; that is the strata are broken and in some parts lie much lower than they do in others. The principal faults in this district run nearly N. E. and S. W. Two of these have thrown the strata on the E. and W. sides from one to two hundred yards lower than they are in the middle. This elevated middle district, which does not affect the surface, is about seven miles in length, and from one to two in breadth, and it is here, on account of the greater facility of working the mines, that by far the greatest quantity of coal and ironstone have been got. The Madeley Wood and Lightmoor works are the only collieries in the eastern depression, which is here called a *swamp*,; and the Ketley and Hadley the most western in the western swamp. The elevated district has several faults running in various directions which have caused depressions, some of which are fifty or sixty yards.—This is a general account of this valuable district.

In the parish of Wombridge the stratum of coal, called the flint coal, incloses in its middle a stratum of canal coal about nine inches thick; this situation in some parts of the same stratum is occupied by a baf.

The so famous spring of mineral tar or pitch (*Maltha* of *Lin.*), exudes from fissures in a sandstone impregnated with it, and lying over a stratum of coal, but from which it is separated by an argillaceous stratum. At this present time it only yields about thirty gallons per week, formerly it yielded near a thousand gallons in one week; and at first, when the level or adit was driving, many barrels were collected in one day. It is supposed that were there a greater demand for it, a much greater quantity could be obtained by driving through fresh fissures. In the upper part of this bituminous sandstone, a great many rounded pieces of coal are imbedded.

In the neighbourhood of this tar spring, several springs of salt water have been found, but none lately of sufficient strength to be worth working. The water which exudes from the flint-coal in some works in the parish of Madeley, is likewise salt; and in the adjoining parish of Broseley there was formerly a salt work, where the salt is said to have been made from water taken out of the coal pits, which, to this day, are called the Salt House Pits. The famous spring which formerly threw out so great a quantity of inflammable air was at Broseley.

The strata of this district, like those of other coal fields, inclose many animal and and vegetable productions; few however in the upper strata. In the ironstone nodules, called the ballstone, the impresions of various ferns are common. In the blackish grey dry clay, called the flint coal roof, a kind of muscle shells and some vegetable impresions are found.

In the sandstone called the flint there is an immense quantity of those vegetable petrifications, or rather impresions, which have been compared with some of the cacti and euphorbia tribes; they are sometimes in cylinders of the thickness of a mans thigh. Another kind resembles the sugar cane, both kinds are of sandstone.—In the Pinny measure, which lies under the last mentioned, no vegetable impresions are found, but some shells of the limpet and cockle kinds.—The bed of dye earth which supports the coal strata contains many of the Dudley-fossils? (*Entomolithus paradoxus*?) and some small bivalves.

The *tophus turbinatus*, *calcarius multicorticatus interne imbricatus* of Linneus, and figured in Table II. Fig. 36 of the second volume of Wallerius, here called curlstone,

forms an almost continued stratum in the Pinny measure, No. 54. The points of the cones always point upwards. It has been occasionally used both as a flux for the ironstone, and, after being burnt, as marl for manure. It dissolves with effervescence in acids, but some of the interior cones are so hard as to strike fire with steel.

The columnar iron ore, the *ferrum basalticum*, Syst. Nat. à Gmel. the *Fer limoneux brun en prismes pentaedres et heptaedres*, &c. of Mr. Bornes Catal. Method. &c. vol. II. p. 283, from Hoschenitz in Bohemia, and other places on the continent, which so well resembles basaltic columns in miniature, is common at Ketley, but this form, here, is the result of torrefaction.—In the limestone quarries at Lincoln Hill, near Coalbrook Dale, large geodes full of fluid pitch (*Maltha. Lin.*) are frequently found.

In this coal district are the following iron works. In the south is Willey, Broseley, Calcot, and Bental; these are on the south side of the Severn. On the north side of this river is Madeley Wood, Coalbrook Dale, Lightmoor, Horse Hay, Old Park, Snedshill, Ketley and Donnington. These works em-

ploy about six thousand hands; and annually about 260,000 tons of coal are raised in this district. It is worth remarking, that Coalbrook Dale can justly claim the merit of having, in the beginning of this century, introduced upon a large scale, the use of coaked coal, as a substitute for charcoal, in the making of iron.

Towards the northern end of the coal district is Lilleshall Hill. Judging from some specimens I have seen it is of jasper, flanked with limestone on its north end and eastern side. Kingley Wich is about two miles west of the same district. It has a spring of salt water which yields four or five thousand gallons in the twenty-four hours. It is an impure brine, but was formerly used; the salt pans and buildings are still remaining. It flows out of a reddish sandstone rock which rests upon a reddish chert, like that of the Wrekin. And at Admaston, near Wellington, only two miles from Kingley Wich, there is a salt medicinal spring, calybeate and hepatic; formerly it was in great repute; it is still much frequented by the lower class of people.—Before we leave this part of the county I must note, that lately a colliery has been opened near Dryton, on

this side of the Severn, about half way between Coalbrook Dale and Shrewsbury.—This is a sketch of the first division of the county.

When we cross the Severn at Shrewsbury, and enter what I have denominated the hilly division of the county, we do not immediately find ourselves amongst those hills which give the title to this appellation. The flat country still continues, but gradually diminishing in breadth towards the south, terminates in a valley formed by the Lawley and Caradock hills on the east, and the Longment on the west.

Passing westward along the banks of the Severn, red sandstone I believe prevails; but about Rowton and Loton Hall limestone is found. Nearly in the same direction, but two or three miles from the Severn, lies another coal district, but trifling in its produce, when compared with that I lately described, with which this seems to be almost connected by the colliery of Preston Boat, and that near Dryton. It begins about Emstree, and extends about a dozen miles westward through Sutton, Meol, Pulley Common, Nobalt, Hooka Gate, Whelbech, Ascot, Pontsort, Pontesbury, Malehurst, Asterley, Inwood, and

Woolaston; and, from near Whelbech, a branch extends a few miles southward to Longdon Common and the Mote.

Near Pontesbury the hilly district begins. Here I only examined the Ponsort Hill, about nine miles from Shrewsbury. This is a hill of very considerable height and steep ascent. Ascending it by its most gentle slope, I found at its base different kinds of chert, as Isabella coloured, greenish white, reddish white; and one of a glandular structure, having brownish red glands, rather cellular at the centre, partly filled up with quartz, which are united together by greenish grey chert; likewise a liver coloured chert or jasper, with flesh coloured streaks. But the hill itself, as far as my observations extend, is composed of dark greenish grey wacké, * greyish black basalt, and finely granulated wacké, or rather grau-wacké, for though carelessly examined this appears to be a homogenous stone, and has the usual colour of wacké, yet, when examined with a lens, it appears to be an aggregate. The aggregate

* This fossil is rather lighter, softer, and of a more earthy texture than basalt.

or sandy nature is very visible on the surface when decomposition has commenced : there is little or no quartzous sand amongst it. I have two specimens which contain fragments of reddish brown petrosilex as big as peas, and one with a rounded pebble, of reddish very fine grained granitello, an inch in diameter.

It is not uncommon for stones of this nature to be taken for wacké and basalt. I find by my notes, made on examining the collections sold by Mr. Lazius, that some specimens in his collections, which he calls traps, are of this kind. The dark greenish grey basalt, of which I saw at Rome several Egyptian antiquities, though called basalt, is of this nature. Mr. Wad, in his *Fossilia Aegyptiaca Musæi Borgiani*, though not expressing the same opinion with me, speaks of the sandy texture of this species of Basalt. This is not a needless microscopic discrimination. In every inquiry into the formation of strata, it is requisite to distinguish between those fossils which are the result of confused aggregation and those of cristallisation.

I found likewise an amygdaloid rock composed of a liver coloured ground, (of wacké?) with glands of white compact zeolite, of a

flesh coloured lamellar substance, resembling barytes, but probably decomposed zeolite; and streaks of a pistachio green substance, like the lapis nephriticus, but which, from its swelling under the blowpipe, and melting into a greenish black glass, like the actynolite of No. 8 from the Caradoc, I suppose to be compact actynolite.

To the S. W. of the Ponsort Hill lie hills of argillaceous shistus. This shistus is rather compact than slaty, and contains a good deal of Mica in extremely minute particles. In these hills are several lead mines. The Sneilbach mines, which lie about four miles S. W. of Ponsort Hill, and about thirteen miles from Shrewsbury, are now but little worked, on account of some part of them being under water. The ore here is the common galena and the steel grained ores, and sometimes the white spatous ore. The vein-stones are heavy spar mixt with calcareous spar and quartz. The vein in some parts is four yards wide. I found some heavy spar or vitriolated barytes so perfectly resembling the aerated, that till I had reduced it to a hepar, I could not believe but that it was the aerated. In the same hills, about two or three miles further south, are the White-Grit mines. These

differ in their products only by yielding a considerable quantity of black jack or blende. Further south there are, I believe, some other mines of the same nature.

To the west of these hills, on the confines of the county, from Westbury, in the parish of Ford, to Montgomery, shistose clay (*schiefer thon*), and shistose argillaceous sandstone or flagstone are the prevailing strata; though at Lee, about a mile south of Worthin, there are rocks both of wacké and of chert. At Wother-ton a very thick vein of heavy spar breaks out; here I am told some lead was got a few years ago. The Longmountain, part of which is in this county and part in Wales, is likewise composed of shistose clay. Of this part of the county I can say but little, having never visited it, and I form this sketch from some specimens for which I am indebted to the kindness of the Rev. Mr. Newling.

If we direct our course eastward from the white-grit mine, we find rocks of brownish grey argillaceous shistus or indurated clay, then a hill covered with large blocks of whin or coarse basalt, and about a mile or two further the Bog mines. These mines are in argillaceous shistus, and produce galena lead

ore, sometimes spatous lead ore, and blende with vein-stones similar to the preceding.

Just above these mines, towards the east, are the Stipers Stones. They constitute a chain of precipitous rocks, of hard siliceous sandstone, which in some parts is of so fine a grain as to resemble chert, whilst in other parts it is nearly as coarse as a pudding stone. These rocks run nearly north and south about two or three miles, and are probably the highest in the county. Judging from some appearances just above the Bog mines, I am induced to think they stand upon a grey compact argillaceous shistus, and this I think continues to the Longment. This shistus is probably the same as that of the mines, only discoloured by the atmospheric influence; it has the same minute particles of mica.

After descending the hill on which stand the Stiper Stones, and crossing the Bishop's-Castle and Shrewsbury road, you come to the Longment. This hill, which is about fourteen miles long and three broad, runs from north to south, and is probably the highest in the county except the Stiper Stones. It belongs to the flat topped hills, but is cut with very deep dells or narrow

vallies. It is composed of what I call compound sandstone, that is a stone which, instead of being formed of grains of quartz, is formed of grains or very minute fragments of other kinds of stone. These here, seem to be of an argillaceous and jaspideous nature, mixed with a few grains of feldspar. This is the nature of the rock in general, and I have seen it in several places, but here and there I have found seams of reddish indurated clay or shistus amongst it; and on the eastern side, about Church-Stretton and All-Stretton, this hill is skirted for about two miles by common grey argillaceous shistus. Near the latter place there is a quarry of coarse whin, which is used for repairing the road, and in another quarry, opened for a similar purpose nearer the village, the shistus is pervaded by some short thick irregular veins of grey chert. Smetcot Common, which adjoins this hill in the north, with the Beaston and Lyth Hills, three or four miles further north, are composed of the same kind of rock; though upon the former common I have observed it in some places become a coarse puddingstone.

In building a cottage on the Longment near Darnford, a very small vein, (not a very thin bed or stratum,) of coal was found. It is really a vein, but not, I believe, an inch thick. On crossing Smetcot Common I found a vein of wacké, and the road between Polderbach and Haberley is crossed by a vein of heavy spar mixt with quartz, above a yard thick.

Near Lebottewood, eight or nine miles south of Shrewsbury, in the valley formed by the Longment and the Lawley and Caradoc Hills, coal and limestone are found. Here the limestone, which is covered by twenty yards of argillaceous strata, is four or five feet thick, and lies above the coal, from which it is separated by about ten yards of similar strata. The coal is about a yard thick. The limestone contains petrifications, and has frequently little chinks and cavities filled with pitch. The coal is chiefly used for burning the limestone; both together only give employment to about a dozen men. About two miles south east, at the foot of the Caradoc, coal and limestone are again found, and were formerly worked.

The Longment is only separated by a narrow valley from a beautiful chain of high

hills, about seven miles in length, running from the north-east to the south-west, composed of the Lawley, the Caradoc, the Elmlyth, the Hazeler and the Raglyth. This valley between the Longment and the Lawley may be about two miles, but it is much narrower towards the Caradoc.

The Lawley, which is the most northern, is about two miles long, but very narrow, with very smooth sides of rapid ascent, clothed with verdure, and uniting at top in a sharp ridge. It is composed of a dark blueish grey, hard, heavy and compact wacké. In some parts a stone similar to No. 5 of the Caradoc, (which will be described immediately) is found. And in many places rocks of light reddish brown jasper and reddish white petrosilex protrude through the soil. Quite at the north end, where the rock has been broken for materials to mend the roads, an imperfect or ill characterised granit or granitoid rock is found. It is composed of red feldspar, white quartz, and blackish green hornblend; but only in the most perfect specimens. In general it is rather of the nature of granitic sandstone, and has some appearance of having been formed by deposition;

a little mica lies between the small beds which are but just indicated. I have some specimens where the components are not distinct and granular; where the quartz and feldspar, mixed with a blackish green earthy substance like wacké, flow into one another. This granitoid stone seems to form only a wedge or patch amongst the wacké. At the south end of this hill I found the same as No. 8, of the following article.

The Caradoc or Quardock is only separated from the last hill by a narrow valley. It is likewise a ridge hill and very similar in form to the preceding, of the same length, and runs in the same direction, but exceeds it in height, and rises considerably in the middle. The north end is composed of greyish coloured sandstone, in which grains of red feldspar and other matter are mixed with the quartzous sand. In some specimens, when examined with a lens, something like pitch is seen to fill the interstices between the grains.—Further south, I found (No. 5) a greenish grey kind of whin or wacké. It is not a homogenous stone, but rather an intimate mixture of a greenish black substance, probably of the nature of horn-

blende, with a greenish white substance which is easily scratched with a knife, and makes no effervescence with acids: then amygdaloid rocks prevail.—First I found (No. 8) a blackish grey compact wacké, very nearly approaching the true compact basalt, with glands, about the size of a large pea, of fasciculated and stellated-fibrous pistachio green actynolite (actinotus). These glands easily melt under the blowpipe into a blackish slag with ebullition; this fossil I don't recollect ever to have read of or seen before. It may be called the *Amygdalites actinotus*.—In the same part of the hill there is a blackish grey wacké very cellular, with small hemispheres of hæmatites, the size of a pin's head, scattered about the sides of the cells. Here likewise small veins of blood red jasper, and some agate are found.—Further south, on each side of the little dell which divides this hill into the Little Caradoc and the Caradoc, great blocks of hard white siliceous sandstone abound. Then the amygdaloid rocks are found again. One kind is a dark brownish red wacké, thickly strewed with very small glands of white zeolite and white calcareous spar; and another is a blackish grey wacké

with cells, only in part filled, with flesh-coloured and white zeolite and calcareous spar, all mixed together. Some of this red substance melted without intumescence or phosphorescence more like feldspar than zeolite; these three different kinds of fossils are so mixed together that it is difficult to investigate them.—The rocks on the top and those still more southward, are of jasper. I have from thence a reddish brown compact jasper. The same but fine-cellular with the sides of the cells invested with green earth. A light brick coloured jasper, dull, and rather softer than a true jasper, with small oblong greenish black spots; and a liver-colour jasper with small oblong glands of white calcareous spar. I have from some part of this hill a black-brown jasper, with two little cavities in which are minute rock crystals, and minute rhomboidal crystals of flesh-coloured feldspar. Wherever there is any appearance of stratification, the strata cross the hill and rise towards the north. It is at the foot of this hill on the western side, that I lately said both coal and limestone were formerly got.

To the south of the Caradoc lies the Elmlyth. This hill is much inferior in height

and length to either of the preceding. Ascending it on the west side I found a singular kind of compound rock, a kind of granitic sandstone, and at the top a dark grey wacké, which in some places is intimately mixed and blended with reddish chert and jasper.

To the east of this, separated by a valley, is the Hope Bewdlar Hill, of which I only examined the south end; this is of porphyry, of a liver-coloured ground of hard wacké with reddish feldspar.

To the south of the Elmlyth lies the Hazelar Hill. At its base, near the high road, there is a quarry of reddish sandstone; but of a very curious kind. If examined with a lens it is seen to be wholly composed of small grains of flesh-coloured feldspar and grains of quartz, with scarce a particle of mica; however, on a nice examination, a few spangles of black mica are discovered. It is quarried for mending the roads. The rocks above, which protrude through the soil, are of liver-coloured wacké.

To the south of this is the Raglyth. The rocks on the very summit are of reddish grey, in another part of light flesh-coloured, chert. But on the western side I found the rock to be

a compound or aggregate stone, very difficult to be described. At first sight it appears as if small particles of reddish feldspar were imbedded in a coarse grey earthy basis; but, examined with a lens, it appears to belong to the compound sandstones; it is composed of grains of feldspar, grains of quartz, and some earthy matter. This hill terminates the chain of primitive hills, which began at the Lawley; and, south of the Raglyth, to a considerable extent, the stratified rocks prevail, which may be seen in the turnpike road to Ludlow. The strata I have observed are of the nature of argillaceous sandstone and flagstone.

If we come back to the Lawley and Caradoc, and then continue our course eastward, we find under both these hills, on their eastern side, a parallel range of white sandstone, which in some places has a very coarse grain. Where it is most regular, as under the Lawley, it presents its escarpement towards these hills, from which it is divided by a small valley. Under the Caradoc on one spot it forms a little conical hill. It extends northward to Frodesly Park, and continues thence in an eastern direction to Buckley, and further eastward forms the high ridge on

which the village of Kenley stands; here it is of a very coarse grain. This ridge runs parallel with the Wenlock Edge.

About two miles N. W. from Frodesly lies Pitchford, and four miles further to the N. W. is Cundover. This country, and all, I believe, that lies from hence in a north east direction to the Severn, is sandstone. Pitchford is famous for a well on which pitch is found floating, and for a bed of sandstone and a sandstone mixt with fragments of grey shistus, both highly impregnated with mineral pitch; this is the stone which is called the British oil rock, and from which the British oil is distilled. This rock is only covered by a few feet of gravel and soil. Coal was got in this parish about fifty years ago, but not in quantity, nor of a good quality.

If we again come back to the east side of the Lawley and Caradoc, and continue our eastern course for a mile or two, to the village of Cardington, we only meet with argillaceous sandstone or flagstone. On this kind of strata the village stands, and thence it extends a considerable way further to the N. E. whilst to the south of the village, on the common, wacké and chert, like those of the Lawley, are found.

Here, some years ago, a trial in mining was made in search of copper, and some yellow copper ore was found, but of no consequence. But the bold craggy rocks near the village are of a very hard compact siliceous white sandstone.

In continuing a S. E. course for two or three miles I met with no rock to give me any hint of the strata here, but on the east side of the village of Rushbury, there is a high range of common grey limestone rocks with petrifactions. They face the chain of hills I lately described, and, running parallel with it, extend several miles both to the N. E. and S. W.

At the back of this lies a similar range of limestone rocks of many miles extent, but higher, and with more prominent features, called the Wenlock Edge. It has the same facing or escarpement, and the same course, and in its N. E. direction extends as far as the banks of the Severn opposite Coalbrook Dale. It is cut by some deep dells or narrow vallies, so as to resemble several promontories, some of which being covered with wood are very picturesque objects. As I followed the inclination of the strata, which of course is nearly

eastward, I saw several thin strata of flagstone lying amongst the limestone.

Continuing in the south east direction I found, near the village of Howgate, two or three miles further, coarse grained sandstone. As I approached the Brown Clee Hill, which lies to the S. E. I met with nothing but immense quantities of loose fragments of true basalt, and in one or two places some red sandstone.

The Brown Clee Hill, and the Titterston Clee Hill which lies three or four miles to the south of the former, are amongst the highest hills of Shropshire, and are, particularly the latter, treasures for this part of the county. They belong to the flat topped hills, but are very irregular in their forms. They are about five or six miles in length, and about half as much in breadth. They resemble each other in their products; both contain coal and ironstone, which in both are in some parts covered by a thick bed of basalt, and this basalt, in each, forms two irregular ridges higher than the other parts of the hill. They further agree in their strata dipping all round from their circumference to the centre, like the sides of a bowl. But they differ

greatly in the quantity of coal they yield. The coal in the Brown Clee Hill only lies in thin strata, and is chiefly worked in a small way by poor colliers, whilst the principal coal stratum in the Titterston is six feet thick.

For the following particulars of the Titterston Coal Fields, I am indebted to the communications of Mr. Thomas Botfield, jun. of Ditton. On this hill there are six different coal-fields, which differ considerably in their extent and thickness. The most extensive and valuable is the Cornbrook ; this is about a mile long and half a mile broad. The two following lists will shew what are the strata in this field. The immense bed of basalt which lies above the coal, is a remarkable circumstance in this part of the kingdom.

*Strata found in sinking the DEEP PIT in the
Southern Part of the Hill.*

			yds.	feet
Earth and Sandstone Rock	....	....	10	1½
Basalt, called here Jewstone	....	....	64	1½
Sandstone Rock, Bind, Clunch, and Coal	}		23	0
Roof. Dry Clays		....		
The Great Coal	....	....	2	0
Coal-bottom and Ironstone Roof. These	}		1	1
are Dry Clays		....		

				yds.	feet
Ironstone Measure.	A dry Clay	....		1	0½
Three-quarter Coal	....	....	....	0	1½
Clumper.	Hard dry Clay	....	....	2	0
Smith's Coal	....	....	....	1	2
The Smith Coal-bottom.	Dry Clay.	}		0	2
Down to the Four-foot Coal Rock					
				107	1

The Strata in the WATER PIT, which is about a quarter of a Mile to the North East of the preceding, are

				yds.	feet
Basalt, here called Jewstone	....	....		48	0
Brown and white Clunch.	Dry Clay	....		6	0
Red Rock.	A yellowish Sandstone	....		9	0
Bind and Clunch.	Dry Clays	....	....	9	0
Pinney Ironstone Measure.	Dry Clay	....		1	0
Clunch.	Dry Clay	....	....	3	0
Brown Rock.	A yellowish Sandstone	....		6	0
Tuff (plastic Clay) and Sand	....	....		1	0
Black Bind.	A dry Clay	....	....	4	0
Rock.	Very coarse Sandstone	....	....	5	0
Strong Clay	....	....	....	1	0
Horse-flesh Earth.	A variegated red and white Marl	....	....	6	0
Grey Rock.	Sandstone	....	....	6	0
Bind.	A dry Clay	....	....	2	0
Great Coal Rock.	Whitish Sandstone	....		6	0
Coal Roof.	Dry Clay	....	....	3	0

	yds.	feet
The Great Coal	2	0
Coal-bottom Pounsins. A dry Clay	1	0
Ironstone Roof and Measure. A dry Clay	1	1
Three-quarter Coal and Basf	0	2
Clumper. A hard dry Clay	3	1
Smith Coal, and Clod in it	1	2
Strong Clunch. Dry Clay	2	0
Flan and Basf. Hard dry Clay	0	2
Strong Clunch. Dry Clay	3	0
Four-foot Coal and Basf	1	0
Strong brown Clunch. Dry Clay	1	0
Sunk into the Four-foot Coal Rock	3	1
	137	0

The Newbury Coal Field, which is in the south end of the hill, is about half a mile long by a quarter broad. This has the same number of beds of coal as the preceding, but they are always about one third thicker. The basalt does not cover the coal in this field, nor is it found in it. The other coal fields, which are likewise never covered by basalt, are of small extent, and have only one stratum of coal from eighteen inches to two feet and a half thick ; or the same divided into two by a thin bed of clay.

What is the nature of the strata that succeed to those mentioned in these lists, has fortunately been pretty well ascertained by the Road-level, which discovered about seventy yards of sandstone strata, mixed with some strata of clay. And from the situation of the limestone in the neighbourhood of this level, it is most probable that many more yards of sandstone lie between those and the limestone. At the lime-works at the Knowl, where there are several beds of limestone alternating with clays mixed with sand, it appears that these lie under the above strata, and form, as it were, the foundation of these collieries.

Were I to say more on the stratification of this hill, it would be merely conjectural. But if it is permitted to make an induction from appearances in the neighbouring brown Clee Hill, with which this agrees in so many particulars, then I may say that there are a great many strata of sandstone, and some with a calcareous cement, lying under the limestone strata. For the limestone bafsets out very high in the southern end of that hill, and from thence to the bottom nothing is seen, wherever the water has laid the rocks bare, but sandstone.

It is conjectured that at the Hill-Work Coal Field (one of the six) the basalt lies under the coal. This little coal field lies upon, or is surrounded by, the Cornbrook Coal Field, and when the coal in this latter field is cut off by a fault in the neighbourhood of the former, the miners in working in that direction have always come to basalt. All these little coal fields, with their accompanying strata, dip all round from their circumferences to their centres, and are to be considered not as parts of one great bowl, but as so many small ones. Canal Coal is found in this hill. On account of the great expence of sinking through the basalt, coal is here about one-third dearer than in the Coalbrook Dale district.

Both these hills, like others similarly situated in this part of the kingdom, have the vestiges of ancient fortifications on their summits. The highest parts of both are inclosed by a dyke or mound, which differ from most others in this, that they are not of earth but of loose fragments of basalt, which are found in great abundance on these hills. The dykes are about six or eight yards broad at their bases, but now no where above three

or four feet high, and seldom that. From these hills the Caradoc and the Malvern hills, both of which have still the remains of fortifications, are distinctly seen; and these, by lying between them, were well adapted to keep up a correspondence by signals.

About two or three miles N. E. lies Orton Bank, which furnishes a great quantity of lime for that part of the country. The lime rock is composed of several strata, varying a little in colour and grain. I observed one stratum of the *Oolithus* (Bath and Portland stone), it lies between strata of common limestone. Sandstone prevails in the neighbourhood. About Kinlet, which is further east, there are some small hills where whin or basalt is found, with small calcareous glands.

Billingsley, two or three miles to the N. E. is a coal country; it produces likewise the argillaceous ironstone. A company has lately established a considerable colliery here. In the wire Forest, and about the banks of the Severn in that neighbourhood, sandstone strata prevail, and likewise from the Clee Hills to Bewdley, on the confines of Worcestershire,

and about Bridgnorth, on each side of the Severn ; and from Bridgnorth in a north east direction to Tong Castle and Weston, on the borders of Staffordshire ; likewise in the most southern part of the county on the borders of Herefordshire I have found sandstone. About Ludlow limestone hills are common. The castle is built upon a grey argillaceous stone, a kind of very fine grained argillaceous sandstone, which effervesces and contains shells, (the *Arenarius glareosus* Syst. Nat. *Cosglareosa*, *particulis impalpabilibus mollis*. Wall.) and this and similar kinds of strata are, I believe, common in this neighbourhood, and to the westward in the hundred of Clun on the confines of Wales.

*Memorandums on the Rocks in the immediate
Vicinity of the City of Edinburgh.*

ON the west end of the hill on which the principal street of the old town is built stands the castle. The hill terminates here in a bold precipitous rock of black-grey compact homogenous basalt. On one side at the bottom white radiated zeolite is found.—It is, I presume, of the siliceous kind, as the less fragile strikes fire with steel, and does not dissolve or form a jelly in acids.

Calton Hill is extremely interesting. The rock on the west side is only visible in a few places. It is chiefly composed of the rubbish and ruins of rocks of the nature of wacké; it is therefore very various in its appearance. The fragments in some parts are a foot or more in diameter, in others they do not exceed the size of peas. I likewise observed on the same side some coarse grained wacké, which slightly effervesces with acids, and contains

a little hæmatites and hornblende. As the rock here is greatly decomposed and generally covered with soil, it is difficult to form a judgment of it. As you ascend, it gradually assumes the appearance of porphyry. I observed some loose pieces of wacké containing globules of calcareous spar.

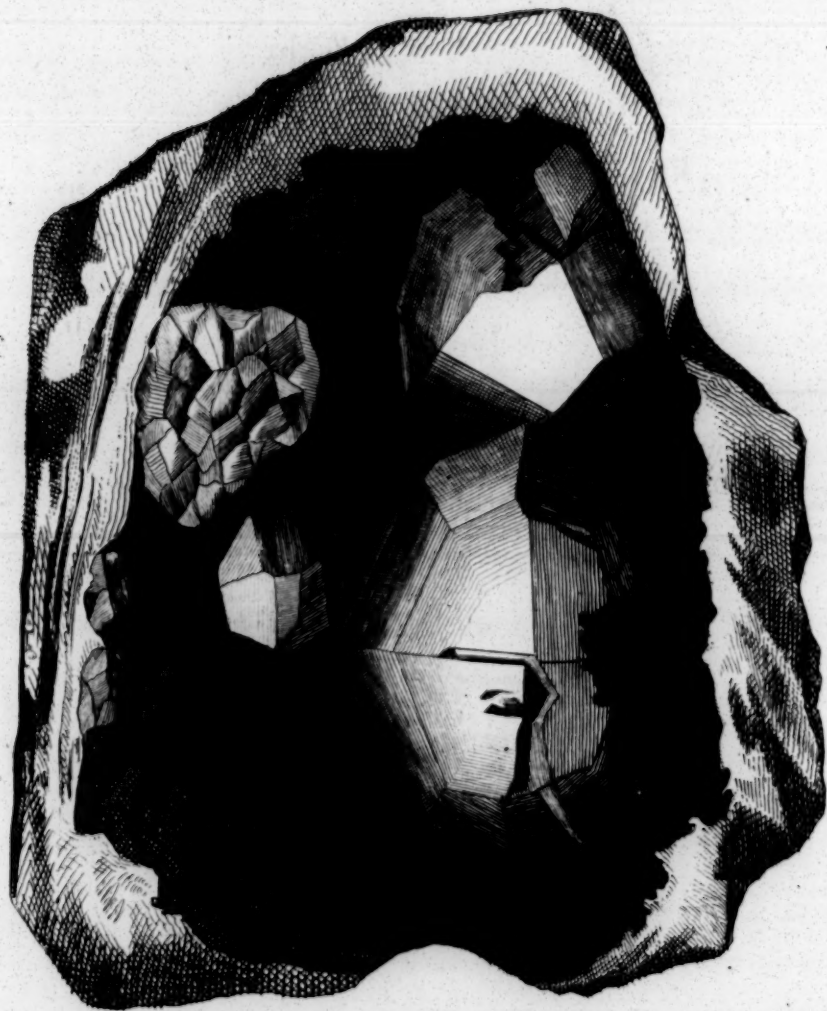
Fortunately for the mineralogist, through the means of a quarry, the rock at the top of the hill is more easily examined. The lowest stratum at this quarry is of breccia about three yards thick, formed of fragments of a porphyrous rock. The fragments are from the size of coarse sand to that of peas, and sometimes larger, of a reddish brown colour, mixed with a considerable quantity of red feldspar, likewise in fragments. This stratum is divided by two or three thin irregular strata of a friable argillaceous mixture, probably the finest part or powder of this breccia.

The stratum of breccia is covered by a bed of porphyry, which, in some places, is twelve or fifteen yards thick. This is divided by an irregular bed about a yard thick, of nearly the same kind of porphyry, but partly decomposed or mixed with something of an argillaceous nature. The porphyry varies

in colour; in one part the ground or basis is of a reddish brown wacké with reddish feldspar, in another part it is of a greenish cast, with the feldspar nearly of the same colour, but scarce visible.

In that variety which I lately mentioned to be mixed with something of an earthy nature, beside the feldspar, there are many small globular and nodulous glands of a red opaque substance like feldspar; yet differing from it by rather superior hardness, and by its fracture, which is not spatous, and by its colour, which is somewhat deeper, and by its form when regularly cristallized, which is the 24 edron, like that of the white vesuvian garnet, called, by Mr. Werner, Leucit, (see the annexed plate)*. It loses its colour and melts under the blow-pipe like feldspar. I consider it as a non-descript, and call it the *SARCITE*. It has not yet, as far as I know, been analyzed. It is only found in the regular form in cavities of the rock, generally imbedded in calcareous spar, and then I think it is of a less florid colour than

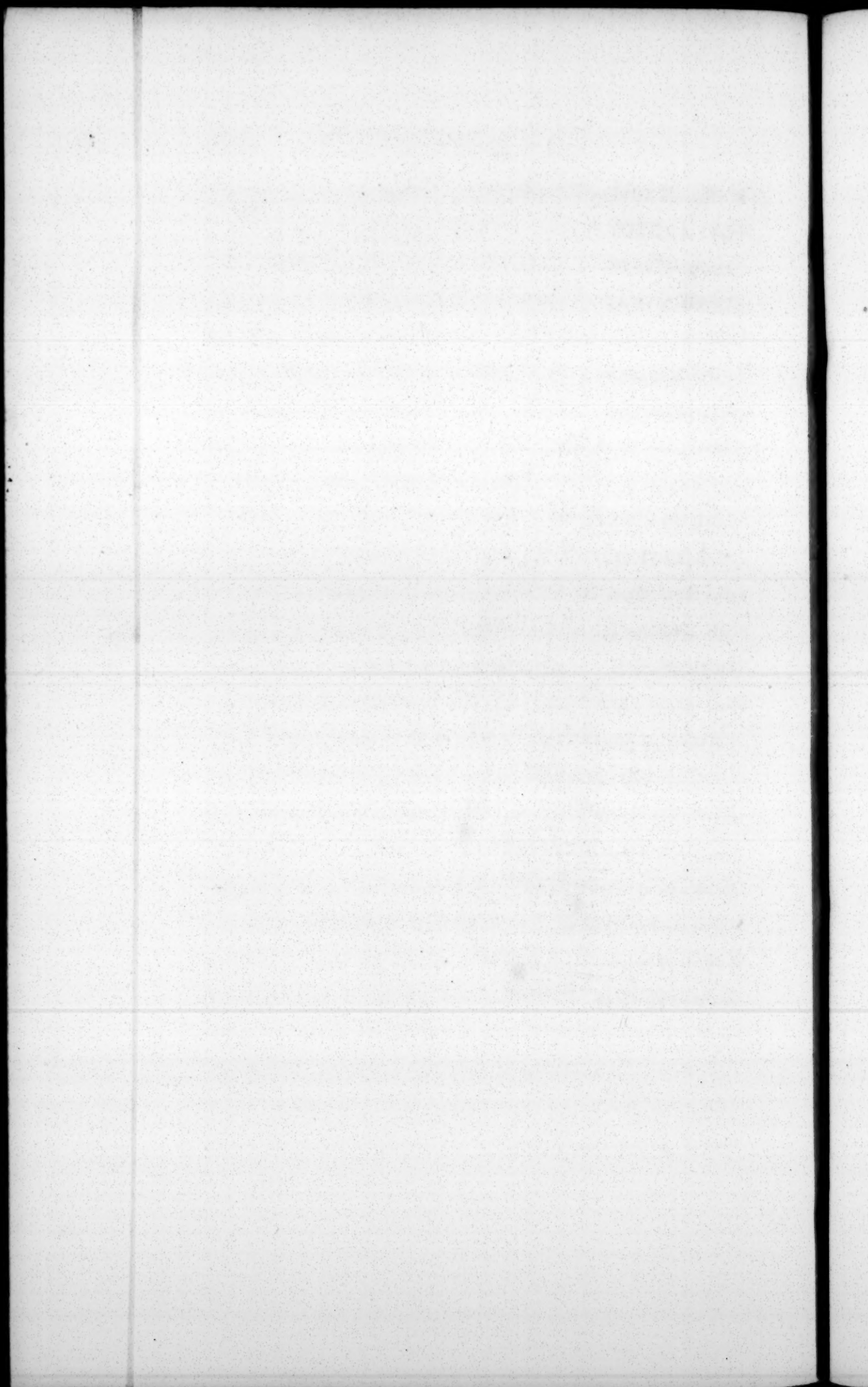
* I sketched this figure from a fine specimen in the collection of Dr. Hope of Edinburgh.



The Sarcite

Alfred, Lord Tennyson

To Face Page. 206.



in its amorphous shape. About a hundred yards to the east is another quarry.

The rocks, which may be seen in St. Ninnion's Row, on the right side of the coach road up Calton Hill, and on the south side of this hill above the north back of the Cannon Gate, are of basalt (or wacké?) interspersed with hornblende. The fissures in these rocks are filled with calcareous spar and a coarse kind of calcedony.

The noble cliffs called Salisbury Craggs are an immense bed of whin or wacké rising to the N. W. At the quarry in the N. E. they are seen to be incumbent on strata of sandstone and indurated clay. The lowest stratum, of which I could only see a few fragments, is a kind of black argillaceous shistus mixed with a little sand and mica. Upon this lies a stratum of light-coloured indurated clay, the thickness of which is concealed by the talus, but a yard of it is visible; it is composed of strata of different colours. Above this there is a stratum of yellowish sandstone about three yards thick; this sensibly effervesces with acids. Over this is a softish friable stone of a reddish colour, which insensibly acquires the nature of the whin that lies above. In another quarry the

lowest stratum visible, under the whin, is of white sandstone four yards thick. Above this is a stratum of very compact siliceous sandstone, of so close a texture as to be a near approach to petrosilex; and over this is a stratum about a yard thick, composed of several irregular strata of the same coarse red petrosilex, sandstone and blueish indurated clays, and then the friable red whin lately mentioned.

Perhaps this appearance of the whin is only superficial, and arises from an incipient state of decomposition. Over this lies the immense bed of whin, which, though one continued bed, varies considerably. At the south end it is a common wacké, which will not strike fire, and sensibly effervesces, and has much less of the fine cristalline texture than it has in other parts, where it strikes fire with the steel, does not effervesce, and has so much the appearance of a fine cristalline texture as to look like a congeries of minute cristalline particles, and in fact, with a lens, hornblende and feldspar may be discerned, and sometimes specks of zeolite, both of a greenish and a reddish colour. I had the good fortune to discover and detach a minute octahedral cristal of the ferrum cristallinum, (magnetic iron ore), and

of this nature I believe the iron to be which abounds in the whins and basalts. When I reduced this whin to powder I could take up the greatest part of it with a loadstone, and that which remained was of a lighter colour. Though this great bed of whin is not distinctly divided into strata, yet there are two or three parallel divisions or fissures which dip with the strata. There are likewise some horizontal veins, if I may call them so, about an inch thick, of a whin, which, by the admixture of red feldspar, has a reddish appearance. Though I have called them veins, on account of their thinness and appearance, yet they are beds or strata, however small, and must have been formed in the same manner and at the same time as the rock in which they are inclosed. I mention them, as they strongly indicate that the whole rock must have been formed by gradual deposition, and cannot have been formed, as Mr. Whitehurst and others have supposed, by being vomited from the bowels of the earth and thrust in amongst the strata.

In two or three places I found small patches like nodules, not sporadic, but congeneric with the rock itself, of the appearance

of fine grained grey granit. They are of white zeolite, mixed with calcareous spar and small laminac of hornblende. In another specimen from Leith shore, tomback brown coloured mica is interspersed.

Over this immense bed of whin lies a bed twelve or fifteen yards thick, formed of many thin strata of reddish coloured sandstone, coarse petrosilex, and blue and other coloured clays. On following this bed we find it forms the sandstone quarry in the King's park, not far off.

At the foot of the talus or slope from whence the craggs rise, there is another sandstone quarry; as the strata here dip in the same direction as the former, it is most probable that they run under them. In the outskirts of the town I remember to have seen some porphyrous-whin rocks, which, from their situation and dip, I thought might very probably run under the former. If it were really so we should then have a most stupendous mass of whin and sandstone strata.

Arthur's-Seat rises from the side of Salisbury Craggs. Its form is very irregular, but rather of a conical form. Its summit is five hundred feet above the plain from whence it

rises, and about eight hundred feet above the level of the sea. Its ascent is bold and rapid, particularly on the north west, but less so on the other side. Its composition is various, and requires a detailed description.

Proceeding from the south end of Salisbury Craggs towards Duddleston Loch, there is on the left hand a high wall or escarpement of basalt, containing both basaltic hornblende, and feldspar, the latter tinged, as it generally is, of the colour of its basis. A little farther it is found in large pentagonal and hexagonal prisms, a yard in diameter, and several in length. Some of them having fallen down, have disclosed some Prehnite* of a greenish white colour, with the incipient forms of crystals on its surface. Near the Loch some siliceous or sandy limestone is found. This I was informed was once quarried for lime, but it did not answer. It appears to run under the hill; little of it is seen. The rocks which overhang the Loch are in one part covered by some fine grained compact siliceous sandstone. In this neighbourhood the basalt contains grains of the

* *Zeolithus viridis*, Syst. Nat.

chrysolite des volcans or* Olivine of Werner. The rocks which overhang the Loch, belong to a chain which continues to the highest part of the hill; behind this there is another similar chain, but bolder, running parallel to it; they both dip to the east; there are similar chains, as I shall soon observe, on the other side of the hill.

If we return towards the basaltic prisms, and climb up the rocks, we then find a kind of platform. The first thing that strikes the naturalist here is the appearance of large blocks of coarse puddingstone, or rather breccia, which lie immediately above the basaltic rocks just mentioned. From this platform an immense rock rises by a gradual slope. As you ascend, wherever the rock appears, nothing but breccia is seen, and the whole rock towards the top being naked, shews that this immense body of rock is entirely breccia. This, again, serves as a platform to another rock fifty or a hundred yards high, but of a very different nature. This is entirely basalt, nearly the same as that below, and has like-

* Olivinus Werner, Syst. Nat.

wise assumed an irregular columnar appearance. Here we are only separated from the summit of the hill by a small valley or dell, from whence rises the rock which forms the summit. This is the same fine homogenous compact basalt as that of Castle Hill which I first described, but of a reddish colour. In consequence of this calciform state of its iron, it does not sensibly move the magnet.

From this elevated situation there are some most beautiful views; the city of Edinburgh beneath, the town of Leith at a small distance, then the Firth, the coast of Fife, and the neighbouring hills. Towards the north the open Sea, the Island of Bafs, and Berwick Lowe, and towards the south the Pentland Hills.—From hence likewise the best idea of the shape of this hill and its neighbouring rocks can be formed. Immediately below, to the north west, there are three ranges or chains of rock behind Salisbury Craggs, similar to them in their course and dip, but on a much smaller scale, and to the N. E. an irregular rock, with its dip and escarpement or front nearly the same. These are the rocks I spoke of when I mentioned similar ranges on

the opposite side of the hill near Duddeston Loch.

On descending towards Salisbury Craggs we again find the breccia, which we saw on ascending the other side of the hill; it continues till near the bottom. Hence it appears that the greatest part of this high hill is composed of breccia formed of fragments of whin and basalt, and which rests upon one bed of whin or basalt, and is covered by another. Breccia rocks do very frequently accompany basalt and its congeners. I have observed them on the other side of the Firth, at Staffa, and in many parts of the continent.

The first of the chains or ranges of rocks that I lately described, as lying at the back of Salisbury Craggs, extends from Arthur's seat to St. Antony's chapel. It is composed of basalt and sandstone, neither of which are like the whin and sandstone of Salisbury Craggs. The basalt is the same as that near Duddeston Loch. The stratified matter forms a bed two or three yards thick near St. Antony's chapel. Some of it is very hard, and strikes fire with steel, but effervesces with acids, and has an argillaceous smell, but the greater part is soft and friable, and seems to be merely the finer

debris and powder of the breccia; perhaps a kind of trafs or terrafs. It contains a great many vegetable impreffions, with the charred matter still existing. They appear to be the same which are so frequently found in the strata that accompany coal. The large irregular basaltic columns at St. Antony's chapel rest upon this.

The second range is not connected with Arthur's Seat. The basalt is the same as the last, with a bed of the lately mentioned stratified matter lying between the basalt. At the north end of this chain, and likewise near St. Antony's chapel, there are large irregular nodules, and sometimes short thick veins of a siliceous kind of limestone of a fine cristalline texture enclosed in the basalt rock; it effervesces and difsolves in acids. Red and variegated jasper are likewise found in nearly similar forms and situations.

The third range is smaller, and not so regular. The basalt is nearly the same as the last, but here I found no stratified matter, nor yet at the insulated rock to the east of it. Further, in the same direction, amygdaloid rocks abound, but of these I find no memorandums. Still further and then the coal strata commence.



A Sketch of the Mineralogy of the Malvern Hills.

THE Malvern Hills consist of a simple ridge of very considerable height, and very steep ascent; about ten miles in extent, running north and south. At the southern end it is less uniform, several smaller hills being there clustered together. On the east side of these hills the country is an extensive plain, but on the western it is hilly, and much higher than on the former. Hence this ridge of hills, if estimated from its base, is much higher on the eastern than on the western side.

The rocks of which it is composed are imperfect or ill characterized granit, imperfect kinds of wacké, chert, and here and there in small quantities micaceous-shistus and hornblende-shistus. These are singularly blended together. In some parts the gra-

nitoid rock, which contains scarce any mica, runs as it were in thick irregular veins, or forms patches amongst the wacké and chert; and these likewise are similarly situated amongst the granit, sometimes the one sometimes the other, forming the principal mafs. All these frequently pafs imperceptibly into each other; hence arise various strange mixtures, and imperfectly characterized fofsils.

In walking over these hills, I collected the following specimens; none of which I found any where to constitute a considerable portion of them, except the granitoid kind; and this, though greatly varying in its nature, I found in considerable rocks on the summit of the ridge between Great Malvern and the Well House.

- No. 1. Red Granit, with scarce any silver mica, and a little hornblende.
- No. 2. Fat Quartz, in which a few particles of red feldspar are imbedded.
- No. 3. Quartz and Feldspar united in equal portions, rather in short stripes than in grains, with a few minute spangles of mica. The different components being in very small

quantities constitute a body, which at first sight appears homogenous.

No. 4. Quartz and Feldspar, in such minute grains as to resemble a sandstone.

No. 5. Red Compact Feldspar?? In this I cannot even with a good lens distinguish any admixture of quartz: but when held in a particular direction, the silver mica is visible. I conjecture this to be of the same nature as the preceding, but to be composed of much minuter parts.

No. 6. Red Granit, or rather Feldspar and Quartz, forming a vein or stripe in spatous (granular) hornblende, which is likewise interspersed with red particles of Feldspar.

No. 7. Two stripes of the preceding granitoid mixture separated by brownish mica.

No. 8. Stripes of the preceding granitoid mixture imbedded in, and separated by, a greenish mass, probably of the nature of hornblende.

No. 9. Red Feldspar in irregular spots or blotches of the size of a large pea,

and in smaller particles, in greenish spatous hornblende.

No. 10. Black Spatous Hornblende, interspersed with small particles of red feldspar.

No. 11. Fine grained Black Spatous Hornblende, interspersed with very few and very minute particles of reddish feldspar.

No. 12. A brown Stone, and, to the naked eye, almost homogenous; but which is a mixture of nearly equal portions of red feldspar and black hornblende; but both in very minute particles.

No. 13. Black-grey Wacké.

No. 14. The same, with a spot of siskin green lapis nephriticus, or kind of jade.

No. 15. A mixture of Hornblende and the same L. Nephriticus, with some quartz, all so intimately mixed as to form nearly a homogenous basis or ground, in which are small streaks and particles of red feldspar.

No. 16. Reddish Grey Petrosilex, including a few particles of pellucid feldspar.

All these specimens are from about three or four miles of the centre of the chain; the other parts of it I never examined.

On the west side of this chain, which is the hilly side, I found compact grey limestone, containing petrefactions; at the only quarry I saw, it lies in perfectly vertical strata, running in the direction of the chain, and close at its base. From the smoke of neighbouring lime-kilns, I judge limestone strata to be very common on this side. But on the eastern side, the plain, near the hills, is formed of gravel; not of rounded but angular fragments of the different kinds of stone I have just described. Near Great Malvern, which is at the foot of these hills, red sand is found.

On Millstone-Rocks.

MANY applications have been made to me for information on the subject of Millstones, and for an account of those kinds of rock which are generally used and best adapted for this purpose.

It seems, from the great esteem which the French Burs are in every where, and from the nature of the process of grinding, that very hard and very cellular stones are best ; and it is therefore very unfortunate that very few of the hardest rocks are in any degree cellular. Jasper, petrosilex, granulated quartz, or compact siliceous sandstone, and granit, are very common rocks, and sufficiently hard ; but they are solid, not porous or cellular ; whilst of the few rocks that are cellular there are very few which are sufficiently hard. Hence we ought not to expect to find good Millstone-rocks in many places.

Millstone-rocks may be divided into three kinds. The simple cellular rocks of *Petrosilex*, the coarse Sandstones, and the cellular black Basalt. Granit, though frequently used, is no more adapted to this purpose than any other hard rock.

Of the first division we have the French Bur, which is a very cellular *petrosilex*. It is the *Petrosilex opacus variis foraminulis inordinate distinctus*, of Wallerius, vol. I. p. 282, excluding the *Synonyma* of *Pumex saxiformis cinerius* Lin. and *Lapis Molaris Rhenanus*, which are the cellular basalt of the third division. The Bur is found in France, but I have never seen it but in the state in which we receive it. Both Mr. Guettard, in his *Hist. de Paris* 1758, and Mr. Darcet, in his *Mem. sur l'action d'un feu egale*, speak of it; unfortunately I have not access to either of these works. The latter, according to Mr. Wallerius, speaks of it as being found in thick vertical strata.

The only rock of a nearly similar nature that I have seen is at Conway, which John Sneyd, Esq. of Belmont, Staffordshire, has leased from the Corporation of that town, chiefly on account of the excellence of some

part of it for the Staffordshire Potteries. The nature of the rock varies considerably. In some parts it is a true petrosilex, but in general, though white homogenous, and of a compact texture, it is opaque and dull (without lustre) and of an uneven fracture. I found some specimens so very nearly resembling the true French Bur that they were distinguished from it with difficulty. The first millwrights and the best judges in London approved of them. These were but some loose fragments I found on the hill, which I examined at the request of my friend Mr. Sneyd, who had observed here, a few years before, some indications of rocks of this nature. Since then, this invaluable country Squire has employed proper workmen to cut out some millstones, but with what success I am not informed. Besides this, so similar to the French Bur, I found a rock of chert, which, where I saw it, seemed principally composed of glands of the same nature, formed of subconcentric crusts, and chiefly hollow in the middle. This, though no doubt, much inferior to the other, must be well adapted for millstones. I saw a very singular mixture in Hungary of reddish jasper or petrosilex and white indurated clay, much used

there, and justly celebrated as a millstone I have thus described it in my travels through Hungary, “ *Porphyrius rubro alboque variegatus cellulosus, ex petrosilice dilute carneo et argilla indurata cana undulatim dispositis. Argilla etiam investit cellularum parietes; vix adsunt adularia et mica.* Both this and that of Conway, belong, I believe, to what are denominated the primitive rocks.

There is another kind of rock, though I think used but little or not at all, which nevertheless seems, by its great hardness and porous nature to be well adapted to this purpose. This is a kind of petrosilex or chert of a very different appearance, nature and origin, from the preceding, and varies, probably, from a close hard siliceous sandstone to petrosilex and quartz. It is the screwstone, the Schrauben-Steine of the Germans, and the pierres à vis ou Trochleares of the French. In this, the cellular or porous texture arises merely from the absence of the petrifications which have been inclosed in it, and of which we now only find their moulds and cavities.* This is by no means a rare fossil, and, though

* See page 109 of the Philosophy of Mineralogy.

considerably varying in its cellular texture constitutes strata. I have seen it at the lead mines in Flintshire, and elsewhere. I know it is found in Derbyshire, and I am informed it is likewise in the Vale of Llangollen. It is probable that this, when employed for millstones, must, like the French Bur, be often used in pieces cemented together. I have seen it in Flintshire so exceedingly cellular and delicate, that it resembled the light spongy calcareous incrustations called petrified moss, and was unfit for millstones. At other times it is not sufficiently spongy or cellular.

The second kind of millstone-rock, and which is frequently emphatically called millstone-rock, *Lapis Molaris*, *Mühlstein*, *Pierre Meuliere*, is a coarse grained sandstone, varying considerably both in the nature and size of its component parts. Most of this kind that I have seen, were of so coarse a grain as to enclose pieces of quartz as big as nuts, and even walnuts. That of Mow or Mole-Cop in Staffordshire, which is in great repute, is of a loose texture, and composed of coarse grains of sand mixed with decomposed feldspar. This kind of millstone-rock, is more

common than either of the preceding kinds, and constitutes thick and extended strata.

The third kind of millstone-rock is the black cellular basalt, the *Pumex molaris* of Linn. the *Lapis molaris rhenanus* of Cronstedt. It is chiefly quarried near Andernach, on the Rhine, in the bishoprick of Cologne; and it is from thence we are supplied with this kind of millstone. No doubt some of the porous lavas of Italy would answer equally well. So far as the cellular texture, this kind is admirably adapted for millstones, but being of basalt or lava, stones of very inferior hardness, it can by no means come in competition with the French Bur. It wears away fast, and as it gives a dark powder it does not turn out a white flour. I found it used in a great porter brewery in London for grinding malt. I have seen nothing in our island exactly of this nature. The cellular traps whins and toadstones of Derbyshire, and elsewhere, are much softer.

These are the principal kinds of millstone-rocks. No doubt, others are used where the difficulty of obtaining the best is so great as to compel the substitution of those of an inferior kind. Accordingly in some parts

granit and granitoid rocks are used, and amongst the *Saxa molaria* of Wallerius, I find one composed of grains of quartz cemented by, or imbedded in, steatite. Another, a kind of gneifs (*Gneifsum alpinum* Lin. à Gmelin), formed of quartz, mica, and garnets; and another of quartz, mica, and shorl or hornblende.

Stone-Henge.

THE situation and form, if not the use and destination of this astonishing work of rude antiquity, are well known; with these I am not concerned, as I mean to speak of it merely as a mineralogist. All the great pillars, as those forming the outward circle, the five pair innermost, and the great stone with the two lateral ones near the ditch, are of a pure fine grained compact sandstone, which makes no effervesence with acids. As far as the lichens which cover the pillars will permit one to judge, some are of a yellowish colour, others white.

The second row of pillars, which bear no proportion in bulk to those just described, and the six which are innermost of all, two of which form the door posts, and another which is grooved, are of a kind of fine grained Grünstein; where the black hornblende is the only constituent which has a cristalline form or spatous appearance. This in some pillars is but sparingly scattered in the principal mass; in others it forms a principal part. The mass or ground has a finely speckled green and white appearance, an uneven fracture, makes a slight effervescence with acids, and may be scratched with a knife. This stone strikes fire difficultly with steel. But in this second row there are two pillars of a quite different nature. That on the right hand is a true and well characterized blackish siliceous shistus, the kiesel schiefer of Werner, that on the left is argillaceous shistus. The great slab or altar, is a kind of grey Cos, a very fine grained calcareous sandstone. It makes a brisk effervescence in nitrous acid, but dissolves not in it; strikes fire with steel, and contains some minute spangles of silver mica.

Remarks on the Flos-ferri.

THE manner in which stalactites are formed, is, I believe, well understood. It is easy to conceive that by the gradual dissipation of a solvent the matter held in solution may be deposited, and assume all the various forms that the solution at one or different times had been in. Thus we can account for the form of any stalactite which has such a one as the dripping fluid can have existed in, either through its own natural gravitation or through the joint powers of gravitation and the attraction of some body in contact, but by no means of those forms in which we know a fluid body could not in any circumstances have been.

Reasoning thus, I am unable to account for the formation of that beautiful fossil the Flos-ferri, found in its greatest perfection in the iron mines of Eisenärtz in Styria, which not only differs from all other stalactites in its forms but in its texture. In regard to its form it is generally branched, but whether simple or branched the parts are by no means straight but curved, and in the same specimen curved in very different directions. Where the branches shoot out, that is at the *axillae*, it is

no thicker than in other parts, and frequently a simple undivided shoot, three inches long, is no thicker towards its base than towards its point. In the direction of its growth, the Flos-ferri differs not less from the common stalactites, whose long cylindrical forms are never found in a horizontal situation, and in which direction we know they never can be formed. Yet in the great mine of spatous iron ore of Styria, I have seen both the sides of a vertical fissure covered with the flos-ferri. The texture of this fossil likewise greatly differs from the common stalactites. It is not compact, nor is it composed of concentric cylindrical plates, but of obliquely divergent fibres.

These peculiarities lead me to think that it is formed in a different manner from common stalactites, and I offer these remarks to those who have an opportunity of observing this fossil in its birth-place, that they may investigate its formation.—It is not foreign to the present subject to mention that a few years ago I found on the side of a chalk rock on the turnpike road, somewhere between Portsmouth and Guildford, a fine white light body resembling very much in its structure, the *byssus*

aurea; being in haste I put a small specimen between the afs-skin leaves of my pocket book, which, when I went to examine, I found reduced to powder. It was insoluble in water, but soluble with effervescence in nitrous acid. It is probable that this singular production was of the nature of the flos-ferri, and might be denominated Inolithus-byfsoides, or Stalactites-byfsoides. But these remarks are only offered as hints to future observers.

A Group of Cristals of Selenite inclosing Drops of Water.

No fact scarce in Natural History is too trifling to record, for many, which in the present state of knowledge may appear unconnected and uninteresting, will, in due time, be digested into form, and connected with their causes and consequences; and as parties now run high between those who attribute the formation of the crust of our globe to fire, and those who attribute it to water, no information that can put the disputants in a better state for carrying on the discusion, without increasing their zeal, should be withheld. I therefore make no apology for thus recording that I possess in

my collection of fofsils a fine group of large cristals of Selenite, in one of which, if not in two, (for I have not my collection by me), there is one or two drops of pure water which has a very considerable space to move in.— Rock cristals inclosing drops of water are by no means very rare, particularly in some of the Hungarian mines; but I do not recollect to have seen, or read of any being inclosed in cristals of gypsum or selenite. This group I got at the great rocks of Gypsum, at Lunenburg, in Germany.

Tremella Nostoc.

DR. DARWIN insinuates in his Botanic Garden, that the Tremella Nostoc, or rather what has often been improperly considered as that plant, owes its “appearance of having been pressed through a hole,” to its having passed through the body of a Heron. In this opinion I think he is mistaken. This vermicular form is the natural form of the Ovi Ducts of Frogs, to which this substance owes its existence.

F I N I S.

